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THE MEMORY IMAGE AND ITS QUALITATIVE FIDELITY.

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CHAPTER I.

LITERATURE AND METHODS.

The problem which is approached in the following pages was suggested by the sections on "Central erregte Empfindungen" in Professor Kuelpe's "Grundriss der Psychologie."[1]

The author here expresses the belief that much work on memory has assumed, without sufficient cause, the presence of a memory image; too often, he thinks, the term 'memory image' has been used to cover the remnants of past experiences, whatever their relations to consciousness. As a consequence, the interpretation of results has not always been reliable. In referring to the associational school of psychology, to which this mistake is, in part, traceable, Kuelpe contends that its

[1] "Es ist aber auch erforderlich zu betonen, dass die reproducirten Empfindungen keineswegs die einzigen Hilfsmittel der Erinnerung sind" (*op. cit.*, p. 188). And concerning recognition Kuelpe says (p. 212): "Wenn man nun in den Fällen, wo eine Empfindung *a* peripherischen Ursprungs daraufhin beurtheilt werden musste, ob sie einer anderen früher erlebten *b* gleich sei oder nicht, angenommen hat, es finde dann eine Vergleichung von *a* mit dem Erinnerungsbilde von *b*, das wir β nennen wollen, statt und es hänge dann von der Treue, mit der β dem *b* entspricht, ab, mit welchem Grade von Sicherheit und Richtigkeit das Urtheil erfolge, so ist dies eine Construction, die nach unserer Erfahrung den Thatsachen keinen angemessenen Ausdruck gibt. Das Urtheil 'gleich' oder 'verschieden' wird vielmehr in der Regel ebenso unmittelbar abgegeben, wie beim unmittelbaren Wiedererkennen das Urtheil 'bekannt.'"

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schema for mental contents—sensations and their weak copies, ideas—is inadequate, and even unjust to experience. Since the days of Locke, we may say, the notion of memory as a faint likeness of perception, and of 'reproduction' as a revival through imagery, has been a common one in psychology. In view of the present limitations of 'associationism,' criticism of such a notion is hardly to be avoided where rigid analysis takes its place alongside logical arrangement in psychological work.

Bearing in mind this fact, we have tried to determine the exact place of the image in the memory consciousness, and have then endeavored to discover the changes which the image undergoes in the course of time. We have set ourselves (1) to examine critically the place given the image in the memory literature, (2) to discuss the nature and function of the image and its genetic significance, and (3) to isolate the image for experimental investigation.

Although the existence and general nature of the memory image were early discussed both in and out of psychology, its more precise investigation has waited longer than most memory problems. The fact that its isolation is secured with difficulty accounts partially for this. Its neglect seems, however, to be mainly traceable to the direction from which the psychology of memory has been approached.

A history of the contributions to memory is not called for here. Several lists of the literature, more or less complete, have been made.[1] A brief sketch of the memory methods and a reference to the aspects of memory investigated will, however, be an aid to perspective and indicate at what point our own work touches the general problem.

The first problem of memory to receive wide attention was the 'reappearance' of past events through the mediation of association. As early as Aristotle, 'laws of association' were formulated which were intended to state the conditions under which ideas are brought again to the mind. Aristotle's formulation was so successful that it has passed current, with but minor modifications, until modern times. In the Empirical school of England the bipartite division of mind into 'impressions' and 'ideas,' and the attempt at analysis, brought again into prominence the concept of association. The well-known doctrine of this school, as just now indicated, asserts that ideas are stored-away sensations, and the task of their evocation is laid upon the 'laws of association,' which thus become of prime

[1] For a general and historical aperçu, see W. H. Burnham (*Amer. Jour. of Psych.*, Vol. II,) on "Memory Historically and Experimentally Considered." A recent experimental bibliography on the subject is given by F. Kennedy, *Psych. Rev.*, V, p. 477; this is, unfortunately, full of minor inaccuracies.

importance for knowledge. As every idea has been before presented as an impression (whence the famous dictum, "nihil est in intellectu, quod non prius fuerit in sensu") its reappearance through association is—so far as the arrangement of the elements is unchanged[1]—an act of memory. It is memory, then, as 'reproduction,' which the traditional English psychology emphasizes.[2]

The doctrine of association is not confined to British borders. The German Empirical psychology of the last century accepted it in a modified form. Such representative writers as Hissmann, Maass and Jacob give association a prominent place in their systems, but do not put upon it so much of the onus of mental synthesis as the developed English school does. A new scheme of reproductive motivation is advanced. There is developed the idea of a more active principle in mind. Ideas are not acted upon, but act. Leibniz' exception, *nisi ipse intellectus*, to the above-quoted dictum finds approval among German psychologists. The *Einbildungskraft* occupies an important place in their outlines. The laws of association, says Tetens (*Phil. Versuche*, pp. 108 ff.), have been over-estimated; they do not exhaust the creative activity of the mind. Reproduction as an active principle receives a more exact formulation later by Herbart and his followers. From the *Vorstellungsthätigkeit* Herbart constructs an elaborate scheme of reproduction. The tendency of the idea is, for Herbart, toward reappearance, and the success of rivals becomes a matter of mathematical calculation.

With the rise of experimental methods, memory attracts investigation in its own name. Among the incentives to recollection, association still holds a prominent place, and some of the inquiries[3] into it throw light incidentally upon various aspects of memory; but it is chiefly to direct investigation into memory itself that we must look for elucidation of memory problems.

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[1] *Cf.* Hume. It seems at first strange that Hume should make the laws of association relate to the imagination instead of to the memory. He comes to this, however, because he is thinking of a *changed* order among ideas, and only a *preserved* order belongs to the memory. The rearrangement of elements is work for the imagination. *Treatise*, bk. I, pt. I, Secs. III and IV.

[2] Spencer, one of its later representatives, thus connects association and memory: "Manifestly, associability and revivability go together; since, on the one hand, we know feelings to be associable only by the proved ability of one to revive another, and since, on the other hand, the revival of any feeling is effected only through the intermediation of some feeling or feelings with which it is associated." *Prin. of Psych.*, I, 251.

[3] Among these are the works of Galton, Trautscholdt, Cattell, Scripture, Bergström, Jastrow, Calkins, Lehmann, Höffding, Offner.

After a glance at the literature, with reference to methods pursued, we shall have to consider how far the problems which memory presents to psychology have been disposed of and what still remains to be done. We shall endeavor to show that the science has taken up the problems from the standpoint of popular and pedagogical interest and has still before it much work, both in the analysis of the memory consciousness and in relating memory to mental processes in general. Afterward, taking up the memory image in particular, we shall outline a static and a genetic account of it which we hope may receive confirmation through special experimental investigation.

First in regard to method. The emphasis laid upon the function of 'reproduction' in the descriptive writings that we have touched upon is carried over into experiment, and we have to take account of a well-defined "method of Reproduction." Co-ordinate with this stands the "method of Recognition." This latter method was suggested by the fact that reproduction, even with the most favorable incentives, does not bring to light all that is retained of a past event. The power to recognize on the recurrence of a stimulus has become a favorite test for memory. These two methods, Reproduction and Recognition, cover practically all the experimental work on memory.

I. Under *Reproduction* we have the following contributors: Ebbinghaus,[1] who deals with the capacity of retention, measuring it by the ratio of retained to forgotten, and with various conditions of retention, *i. e.*, length of series, meaning, time interval, repetition, order, rhythm; Müller and Schumann,[2] who used E's materials with improved apparatus (Müller and Schumann extend E's results and make a special study of rhythm as a condition of retention); Jacobs,[3] who uses E's method with school children; Smith, T. L.,[4] the same method applied to muscular memory. The character and simplicity of stimulus, combination of sense modes involved, association and order, effect of age and race, and individual differences, as well as the conditions already named, have been investigated by Paneth,[5] Münsterberg,[6] Bourdon,[7] Lewy,[8] Bigham,[9] Baldwin,

[1] "Das Gedächtnis," 1885.
[2] "Exp. Beiträge z. Untersuchung d. Gedächtnisses." *Zeitsch. für Psych.*, VI, pp. 81 and 257.
[3] "Exps. on Prehension." *Mind*, XII, p. 75.
[4] "On Muscular Memory." *Amer. Jour. of Psych.*, VII, p. 453.
[5] "Versuche ü. den zeitlichen Verlauf d. Gedächtnisses." *Centralblatt für Physiol.*, IV, p. 81.
[6] *Beiträge z. exp. Psych.*, Heft IV, p. 69.
[7] "Infl. de l'age sur la mém. immed:" *Revue philos.*, XXXVIII, p. 148.
[8] "Exp. Untersuchungen ü. das Gedächtnis:" *Zeitsch. für Psych.*, VIII, p. 231.
[9] "Studies from Harvard Psych. Lab.:" *Psych. Rev.*, I, pp. 34 and 453

Shaw and Warren,[1] Smith, W. G.,[2] Barth,[3] Bolton,[4] Kirkpatrick,[5] Schneider,[6] Smith, W. G.,[7] Whitehead,[8] Hawkins,[9] Daniels,[10] Beaunis,[11] Binet and Henri,[12] Xilliez,[13] Bowditch,[14] Jastrow,[15] Courtier,[16] Vaschide,[17] Shaw,[18] Scripture,[19] Henri, V. & C.,[20] Cohn,[21] Philippe,[22] Wolfe,[23] Galton,[24] Scripture.[25]

II. The method of *Recognition* is represented by the following: Weber[26]—visual lengths and weights, Wolfe and Hirschberg[27]—tones, Lehmann[28]—brightnesses and odors,

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[1] "Memory for Square Size:" *Princeton Studies*, Sept., 1895.
[2] "The Relation of Attention to Memory:" *Mind*, N. S. IV, p. 47.
[3] "Untersuchungen ü. den Ortsinn u. ü. das Gedächtnis desselben:" Dorpat, 1894.
[4] "Growth of Memory in School Children:" *Am. Jour. of Psych.*, IV, p. 362.
[5] "An Experimental Study of Memory:" *Psych. Rev.*, I, p. 602.
[6] "Ueber das Gedächtnis f. active Bewegungen:" Dorpat, 1894.
[7] "The Place of Repetition in Memory:" *Psych. Rev.*, III, 21.
[8] "Visual and Aural Memory Processes:" *ibid.*, III, 258.
[9] "Memory Types:" *ibid.*, IV, 289.
[10] "Memory After-image and Attention:" *Am. Jour. of Psych.*, VI, 558.
[11] "Récherches sur la mémoire des sensations musculaires:" *Rev. philos.*, XXV, 569.
[12] "La simulation de la mémoire des chiffres:" *Rev. scient.*, LI, 711; and "De la mém. vis. des enfants:" *Rev. philos.*, XXXVII, 348; also *L'Année psychol.*, I, pp. 1 and 24.
[13] "La continuité dans la mém. immed.," etc.: *Année psychol.*, II, 193.
[14] "A Comparison of Sight and Touch:" Bowditch and Southard: *Jour. of Physiol.*, III, 232.
[15] "Perception of Space by Disparate Senses:" *Mind*, XI, 539; and "Memory and Association:" *Educ. Rev.*, II, 442.
[16] "Communication sur la mém. mus:" *Dritter Intern. Cong. f. Psych.*, p. 238.
[17] "Récherches exp. sur la mém. des lignes:" *Dritter Intern. Cong. f. Psych.*, p. 454: and "Sur la localisation des souvenirs:" *L'Année psychol.*, III, 199.
[18] "A Test of Mem. in School Children:" *Ped. Sem.*, IV, 61.
[19] "Researches on Mem. for Arm Mvmts:" *Yale Stud.*, V, 90.
[20] "Enquête sur les prem. souvenirs de l'enfance:" *L'Année psychol.*, III, 184.
[21] "Exp. Untersuchungen ü. das Zusammenwirken des akustisch-motorischen u. des visuellen Gedächtnisses:" *Zeitsch. für Psych.*, XV, p. 161, and *Dritter Intern. Cong.*, p. 456.
[22] "Un recensement d. images mentales:" *Rev. philos.*, XLIV, p. 508, and "Les transformations de nos images mentales:" *ibid.*, XLIII, p. 481.
[23] "Size of Familiar Objects:" *Am. Jour. of Psych.*, Jan., 1898.
[24] "Exps. on Psychometric Measurements:" *Brain*, II, p. 149.
[25] "Ueber den assoc. Verlauf der Vorstellungen:" *Phil. Stud.*, VII, p. 50.
[26] *Der Tastsinn und das Gemeingefühl*, 1851.
[27] "Untersuchungen ü. das Tongedächtnis:" H. K. Wolfe: *Phil. Stud.*, III, p. 534: v. Art. by W. v. Tschisch: *Dritter Intern. Cong. f. Psych.*, p. 106.
[28] "Ueber Wiedererkennen:" *Phil. Stud.*, V, p. 96.

Münsterberg[1]—colors and digits, Bigham[2]—visual and auditory complexes, Baldwin, Shaw and Warren[3]—memory for square size, Schumann and v. Tschisch[4]—sounds, Loewenton[5]—space memory for the skin, Binet (*cf.* under "Reproduction")—memory for visual lengths, Bourdon[6]—letters and words, Dauriac[7]—music, Landau[8]—muscular sensations, Saborski[9]—memory for shadows.

Beside these methods, A. Binet suggests[10] the methods of *Comparison* and of *Description*. The first of these indicates a comparison of a memory with a perception and a judgment of likeness or difference; the second, as the name implies, simply a description from memory. Binet reserves the term recognition for the selection from a series of a given remembered member. J. M. Baldwin uses the method that Binet calls *Comparison*, and designates it *Identification;* Binet's *Recognition* he styles *Selection*.[11]

We have taken the words 'reproduction' and 'recognition' as convenient rubrics under which to bring various bits of work from many independent sources. These fragments represent divergent schools of method and many different points of view. The words reproduction and recognition are, however, in common usage, and, in order to an evaluation of results, they demand a critical estimate.

First concerning reproduction. It has been pointed out that the terms reproduction and recollection are extremely liable to misunderstanding.[12] The 'copy' view of memory ideas fostered

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[1] "Studies from Harvard Psych. Lab.:" *Psych. Rev.*, I, p. 84.

[2] *Ibid.*, p. 453.

[3] *Princeton Studies*, Sept., 1895.

[4] "Ueber das Gedächtnis für Komplexe regelmässig aufeinander folgender gleicher Schalleindrücke:" F. Schumann: *Zeitsch. für Psych.*, I, p. 75; W. v. Tschisch: *Dritter Intern. Cong. f. Psych.*, p. 95.

[5] "Versuche ueber das Gedächtnis im Ber. des Raumsinnes der Haut:" Dorpat, 1893.

[6] "Obs. comp. sur la reconnaissance, la discrimination et l'association:" *Rev. philos.*, XL, 153.

[7] "La mém. musicale:" *ibid.*, XXXIX, 400.

[8] Das Gedächtnis für Muskelsinn: *Wissenschaftl. Revue*, 1896.

[9] "Ueber das Gedächtnis f. Gesichtswahrn.:" Dorpat, 1894.

[10] *See Introd. à la psychologie exp.*, 1894, chapter on *Memory*, and experimental articles in *Revue philosophique*.

[11] *See Report of the Amer. Psych. Assoc.* for 1893, *Psych. Rev.*, II, 236, and *Année biolog.*, I, 607. Naturally the corresponding methods differ somewhat in detail in the hands of the two independent investigators. It is to be noted that Binet's classification falls, in point of time, between Professor Baldwin's report and later publication.

[12] *Cf.* F. H. Bradley (*Principles of Logic*, bk. II, Part II, ch. 1,), who criticises these concepts from the standpoint of logic.

O. Kuelpe, *op. cit.*, pp. 189-90.

J. Ward: *Mind*, N. S. Vol. II, p. 361. Dr. Ward says: "thus re-

the notion that reproduction is the sole vehicle of memory. Perceptions were reanimated, and brought to their new incarnation knowledge of their previous existence. Kuelpe has pointed out that so far from reproductions being merely weakened copies of sensations, they may vary in a number of ways from the latter. In fact, that recollection may be satisfied with one of a great number of marks or 'tags' by which a consciousness may refer to the past. He further makes evident that the similarity of a peripheral and a reproduced sensation is often remote, and at best the reproduced sensation is only schematic, and demands various aids, such as words, movements, organic sensations and feelings, to complete recollection (pp. 186-9). These aids may, in fact, become the real vehicle of retention, and one and the same memory stimulus may hold at its disposal a number of them. A visual stimulus, *e.g.*, may be remembered, not by a visual image alone, but by a number of auxiliary processes. There is, here, in short, a principle of vicarious functioning among mental contents. An instance may make the point clear. The writer set himself to memorize a series of digits shown successively from a drop behind a screen. Upon trying to reproduce the series immediately he found that recollection could be mediated in any of the following ways: (1) through visual images, (a) successive in time or space, or (b) grouped—hundreds, thousands, etc.,—*plus* motor memory; (2) auditory-motor images; (3) muscular images, through (a) the throat, or (b) spatial position on the table before him, indicated by pointing with the hand; or (4) the digits were retained by the imaged sound, and translated back into visual terms. Again, with a more complex series, reproduction may be aided by recognition of stimuli presented visually or auditorily. This instance will serve to show, further, the extensive field for analysis in determining, not *how much* of a simple or complex presentation can be retained for a given time under given conditions—external and internal—but *what* is the nature of the memory consciousness.[1]

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tentiveness, recognition, reminiscence, recollection are more or less lumped together as 'memory.' Ideas are described as 'faint impressions' due to central excitation; and all complexity, ascertained or inferred, is put down to 'association.' In consequence the lower animals are often credited with ideation and memory on evidence that only warrants the attribution of perception. Yet there are facts enough in human experience that show the wide difference between perception and ideation; but these facts are too liable to be confused so long as the same term 'reproduction' is applied both to the 'representative element' in perception and to the free ideas of memory and imagination."

[1] Since this chapter was written, this aspect of the subject has been again brought into prominence by Dr. Kennedy: *op. cit.*, p. 483.

Next concerning Recognition. The experimental investigation of memory through recognition dates from E. H. Weber's work with lines and weights. Weber noted that accuracy of recognition decreased with time, so that small differences became, after a time, imperceptible. Wolfe's study of tonal memory has already been referred to. He follows Ebbinghaus in seeking a ratio for amounts retained and forgotten, but uses instead of reproduction the method of recognition. The modus of recognition Wolfe assumes to be the comparison of a stimulus with a memory image. He says: "Gehen wir näher auf das Verfahren beim Vergleichen zweier durch einen Zeitraum getrennten Töne ein, so ist klar, dass ohne ein Erinnerungsbild des ersten Tons eine Vergleichung überhaupt unmöglich ist. Dieses Erinnerungsbild ist gewissermassen der Massstab an welchen der zweite oder Vergleichston gemessen wird. Bliebe das Bild in unserer Erinnerung unverändert, so wurde, wenn unsere Apperception dem Reize genau entspricht, der kleinste Unterschied immer bekannt werden." This memory image, according to Wolfe, may be already in consciousness when the second tone comes, or the second tone may call it forth (*loc. cit.*, pp. 556–58). Lehmann later uses the method to settle the respective claims of contiguity and similarity as associational connectives. Lehmann worked chiefly with gray discs. He accepts (*loc. cit.*, pp. 118–19) Wolfe's assumption of the memory image for recognition of simple objects, and concludes that, for the memory of grays, recognition consists in (1) the visual image or (2) a name. Through the mediation of this image Lehmann finds an association by contiguity sufficient for all cases of simple recognition. This result we are not here directly concerned with; but the assumption of the image upon which the result rests we shall have occasion to criticise in connection with our own investigations.

Lehmann's work was followed by a long discussion on "Wiederkennen" by Professor Hoeffding[1] in the "*Vierteljahrsschrift*" (1889–90). Like Lehmann, Hoeffding approaches the problem of recognition from the side of association. He discusses "Immediate Recognition,"[2] where no reference to the past or to attendant circumstances is traceable, and finds in place of an explicit association by which the presentation is known, a "quality of knownness" (*Bekanntheitsqualität*). The 'thing-known' consciousness refuses to be analyzed further than this: it is a case of implicate (*gebundene*) memory.

[1] Dr. Lehmann's earlier article (1889) has special reference (*l. c.* p. 97) to Hoeffding's doctrine of Association as set forth in his "Psychologie in Umrissen."

[2] An instance: a foreign word which one cannot translate but which has yet a familiar sound (*loc. cit.*, 1889, p. 425).

Whatever reproduction there is fuses with the presentation and loses its freedom.[1] The quality of knownness corresponds to increased facility of disposition[2] among nervous elements. Lehmann criticises this view, and doubts that ease of molecular movement in the cortex could be paralleled by a new conscious quality, *i. e.*, that ease of movement should have as independent a conscious concomitant as movement itself (*Phil. Stud.*, VII, pp. 180 ff.). Immediate recognition is, he says, complex and demands the presence of a memory image, or, at least, a name. Lehmann further does the impossible (according to Hoeffding), and brings immediate recognition under experimental conditions. He shows that odors may be pronounced 'known' without the arousal of any association, even a name. In these cases Lehmann assumes an association whose associated member is subliminal. This brings immediate recognition under the head of contiguity association, but only by doubtful reference to 'unconscious reproduction.' Lehmann's further point, that the feeling tone of odors varies independently of the 'knownness' or 'unknownness' of the stimulus, and hence cannot mediate recognition, is overruled if the feeling of recognition is assumed to be unique. This assumption has lately been supported by Professor Washburn (*Phil. Rev.*, VI,

[1] *Cf.* Spencer's scheme of Association. He says (*Princ. of Psych.*, Vol. I, p. 256): ". . . . The primary and essential association is between each feeling and the class, order, genus, species and variety of preceding feelings like itself. This association . . . . constitutes the very recognition of each feeling." A. Bain takes a similar position (*Senses and Intellect;* third ed., p. 458). Dr. Ward, criticising this view, says: "The characteristic peculiarity of this process of assimilation or immediate cognition is that there are not two presentations, A and B, directly given as a part of the fact to be explained. Two presentations have simply been assumed in order to bring assimilation within the range of the more comprehensible processes of association." (*Loc. cit.*, p. 353.)

Ward prefers to call the process of recognition assimilation, and emphasizes its subjective, apperceptive side. "The mere sense of familiarity or facility is then but a subjective state partly active, partly emotional." (p. 532.)

There has been some confusion, in the literature, of 'cognition,' 'association,' and 'recognition.' On this see A. Allin, *Amer. Jour. of Psych.*, VII, pp. 237 ff., February, 1896; also M. W. Calkins, *Psych. Rev., Monograph Supplement*, February, 1896.

[2] Ward criticises Hoeffding for wavering between nascent ideas and a feeling caused by ease through repetition, as explanations of immediate recognition. The criticism seems to us perfectly just. M. Offner (*Philos. Monatshefte*, 1892, pp. 406 ff.) argues that the ease in recognition must be translated into some other terms in order for the presentation to be known as a repetition. Hence it is not ultimate, *i. e.*, it is not 'immediate recognition.' *Cf.* Külpe, *op. cit.*, p. 179.

For the physiology of Hoeffding's 'ease' *cf.* Van Biervliet; *La Mémoire*, 1893.

p. 267), who makes the feeling of recognition a "peculiar property of centrally excited sensations,"[1] and suggests that it may be paralleled by excitation of connective brain tracts which mediate such sensations. These connective tracts thus perform a function for feeling similar to the ideational function which Spencer gave them as substrate for ideas of relation (*Princ. of Psych.*, I, p. 270). Wundt also speaks of a 'feeling of recognition' (*Phil. Stud.*, VIII, pp. 351–5), but demands ideas in the background. Professor Baldwin's explanation (*Mental Development*, 1895, pp. 313 ff.) differs from Hoeffding's only in placing the 'ease' of recognition in motor phenomena connected with the attention. An attempt at analysis of what Hoeffding calls the quality of knownness has been made by Kuelpe. Kuelpe thinks that it consists "(1) in the especial effectiveness for central excitation of familiar impressions or memory images, and (2) in the characteristic mood which they ordinarily induce and which embraces both pleasurable (or at least comfortable) affective states[2] and the corresponding organic sensations" (*loc. cit.*, p. 178).

Later investigations of recognition (see list above) add little to the method. The process of recognition is left in an unsettled state, though its quantitative expression of retention has been much dwelt upon. The discussions at least raise a doubt whether reproduction, in its real sense, and recognition do not stand for quite different processes. This point awaits further investigation.

The method of *Comparison* (Binet) is easily brought under Recognition in the broad sense in which we have used the latter word. In the meaning that Binet gives the terms the chief difference seems to consist in the number of decisions made by the observer. In his Recognition (Baldwin's Selection), unlikenesses are observed until the desired member of the series is found, and then a judgment of likeness is passed: in his Comparison (Baldwin's Identification), one judgment of likeness or difference suffices, *i. e.*, Recognition is reduced to its lowest terms as regards its object.

Description, similarly, for present purposes of classification, may be subsumed under Reproduction: it is verbal-motor reproduction. It seems not to have been much used as a memory method. It has two disadvantages: (1) its report must always be inadequate and (2) involve other organs than the

[1] *Cf.* B. Bourdon (*Rev. philos.*, XXXVI, 630): "reconnaissance est une sorte de *sentiment*."

[2] The effectiveness of mood in memory has recently been remarked by R. MacDougal (*Psych. Rev.*, V, 463), who contends that music at times creates a mood which, once instituted, attracts appropriate imagery.

ones receiving a memory stimulus. On the other hand it has a decided advantage where complex stimuli are used and direct 'reproduction' is impossible. As Binet suggests, it might be used to test the accuracy of memory for past events which were not at the time of their occurrence translated into verbal terms. Description is the memory method of every-day life, but has not yet commended itself to the experimental psychologist. A phase of 'reproduction' quite analogous to the method of description, and identical with it in principle, is the representation of a visual stimulus through the hand, *i. e.*, a form drawn, or a color painted or mixed in solution, or again, a visual length reproduced on paper.[1] The constant errors in all these cases demand special attention.[2]

We shall attempt to show (Chap. III) that a complete catalogue of methods must take into account the presence or absence of the memory image, a condition which the current methods imply but do not usually fulfill.

Reference to the more important experimental contributions to memory reveals a general tendency to emphasize memory as power of retention. This power has, of course, no direct organic expression; hence it can only be inferred from reproduced or recognized contents. Retention becomes a capacity measured in one of these two ways. The important work of Ebbinghaus, which has served as model for numerous later inquiries, takes up the problem, *How much is retained under given conditions?* He finds, *e. g.*, that, other things being equal, retention is a function of time elapsed. There is little to indicate what the memory consists in—what a cross section of memory contents would show; whether the presentation is carried over, modified or unmodified, by memory, or replaced

[1] Work similar to this is suggested by J. McK. Cattell (*Science*, N. S. II, 761) and repeated by F. E. Bolton (*Psych. Rev.*, III, 286) and Franz and Houston (*Psych. Rev.*, III, 531). Dates, events, distances, weights, forms, etc., were recollected by their pupils and put down on paper. The records show a confusion of observation and retention capacities and have little value as memory results. Thus, *e. g.*, the members of a class were asked to indicate the time taken to walk some familiar distance. The result is not primarily a memory result at all, since it does not show what the several individuals knew and remembered, but only an estimate (from various data) of something which they did not know directly. This fact, of course, does not bias their anthropometrical application, which Cattell indicates.

[2] A case in point is the work of H. K. Wolfe, on "The Memory for size of familiar objects" (*Psych. Rev.*, January, 1898). Wolfe found that some familiar objects, as bank notes, were under estimated when drawn in outline on paper. Plainly this fact does not necessarily report the visual image of the note, since reproduction might easily be biased by the introduction of alien senses, *i. e.*, pressure, muscular exertion, etc. In fact, by different methods, Baldwin (*loc. cit.*) finds that square size is *over estimated* in memory.

by wholly different contents subserving retention. Wolfe, indeed, criticised Ebbinghaus's method as involving too complex conditions; but his own results are the same in kind, *i. e.*, they register the capacity for retention—in this case for tones. Recognition, he asserts, is mediated by a comparison of a tone heard with the image of one remembered, as we have seen. The possibility of other operations in the memory, he does not consider. Still, the material used—tones with small pitch-differences—is probably the simplest available. It cannot be said that Lehmann's work deals primarily with memory. He uses Wolfe's method to ascertain the form of associative connection in recognition.

Beside the capacity for retention of nonsense syllables (Ebbinghaus, Müller and Schumann, and Jacobs), and of tones (Wolfe, Hirschberg and Courtier), we have similar results for retention of letters (Cohn and Smith, W. G.), time interval (Paneth), visual length (Weber, Binet and Henri, Vaschide and Münsterberg), visual size (Baldwin and Wolfe), digits (Bolton, Münsterberg, and Binet and Henri), extent and direction of movement (Münsterberg, Schneider, Smith, T. L., Beaunis and Bowditch), lifted weights (Weber, Wolfe, Landau and Müller and Schumann), tactual space perceptions (Barth and Loewenton), colors and brightnesses (Lehmann and Münsterberg), noises (Schumann), letters and words (Bourdon), and odors (Lehmann).

We intimated above (p. 4) that the course of the work pursued in memory is largely explicable if we take account of popular and traditional conceptions of memory which psychology seeks to make coherent and definite. The case has many analogues in the history of science and philosophy; learning finds its problems ready-made in the medium of common thought. In the instance before us, memory has an obvious importance for mankind. The power to retain and revive experiences is continually put to the test. It is not surprising, therefore, that we find this aspect dwelt upon in popular reflections upon the human mind,[1] and the rise of experimental methods naturally lays emphasis upon the *quantitative* statement of memory's capacity.

Again, the value of much of the work of this kind for practice is apparent. Education gains by any careful inquiry into the human mind. To see science pressed by practice for contributions to utilitarian ends is not unusual. The natural sciences and their corresponding arts afford many

[1] One seems to see a direct connection between the loose ends which experience brings to reflection upon mental phenomena and the generation of a 'faculty psychology' which conceives the mind as a bundle of powers, or capacities for practical activities.

instances of this; medicine, *e. g.*, gathers tribute from physiological estimates of bodily function. A similar levy is laid upon psychology by pedagogy. The *practical* bearings of the facts of habit, attention, memory and apperception explain the drift of much material collected upon these aspects of mind. Reference to systematic works on pedagogics shows, on the one hand, the assumed importance of these rubrics for the art of teaching, and, on the other, their dependence upon psychology.

It is, nevertheless, clear that the quantitative aspects of memory and attention do not exhaust them for psychology. Consider memory. So far as we have looked into the literature, analysis has been seen to play a minor part. The contributions to the subject have measured the volume of the stream and the pressure at given points, to a neglect of the contents. Conventional terms have, in many cases, been substituted for analytic work. One step in advance has indeed been made A general 'faculty' of memory has been resolved into a plurality of memories. Mental pathology, nerve physiology, and psychological experiment have brought about this advance. Some attempt has also been made to ascertain the dependencies of one sense-memory upon another; *e. g.*, Cohn attempts to control the acoustic-motor and visual memories and to show the effect of their combination and isolation. Whitehead and Smith, T. L., have made similar attempts, and Binet compares two extraordinary memories, one a marked visual, and the other an auditory type. Galton goes still further and makes independent exploration into the capacity for visual imagery among various classes of individuals (*Inquiries into Human Faculty*, pp. 83 ff.).

The work which we propose to outline in the following chapters is directed primarily to the analytic side of memory;[1] to

[1] It remains to be said that Dr. Kennedy (*op. cit.*) has already pointed out the lack of analytic work in memory investigations and has urged its importance. There are, however, two or three places in his treatment of memory problems in which we disagree with this writer. These seem important enough to mention. They are the following: (a) 'Recognition,' he says, is distinguished from 'reproduction' only by the "expression on the part of the reagent of the state of the condition of the memory:" *i. e.*, by the memorial report. Plainly, there is a failure here to distinguish between 'direct' and 'indirect' sensible discrimination; between the experience and the report of the experience. When the writer makes every experiment on memory fall into two parts: A, the stimulus, the thing to be remembered, and B, the report (478), he leaves out just the important factor, namely, the psychological experience. This he does bring in later as the image, which he makes essential to any memory (485), but he does not recognize its importance for method. In our view (1) method properly turns on the *psychological* factor, and here (2) we may, or we may not, have a memory image, as we have before indicated. (b) Our experience con-

the contents of the memory consciousness, and more particularly to the part played by the memorial image. The following chapter will consider the image in its genetic and functional connections as a preface to the experimental inquiries into its nature and fidelity.

CHAPTER II.

The Genesis and Function of the Memory Image.

The term 'Image' has a wide significance in Psychology. Its original close connection with vision—the retinal picture or image—is apparent. The use of 'image' as 'retinal picture' is moreover not wholly technical; the word has a like significance in every-day life. The image is the copy of the *real* in ordinary speech; the eye, like a mirror, reflects, reduplicates 'the world.' It is then but a step to the image as a picture of the memory. "The face is graven on my memory," we say, as if it were an intaglio cut in stone.[1]

The language of psychology has extended the term memory image from its connection with vision to various mental contents which represent a definite past event, without regard to the sense affiliations which the contents may reveal. Psychology has also added to the nomenclature of imagery the terms 'positive after-image,' 'negative after-image,' 'memory after-image,' phantoms of sensory memory, hallucinations and illusions. Fechner was the first to complete the list and to give a

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tradicts Dr. Kennedy's distinction of (1) "immediate" (simple) and (2) "mediate" (complex) memory materials; *i. e.*, we are said to remember a thing (1) directly, "as it appeared in reality," or (2) "by means of concepts." We do not find that a thing is remembered "mediately," "conceptually," by "classification," when or because it is complex: one's memory of a man or a house *may* be direct, may be simply a visual image or, on the other hand, one's memory of a simple visual quality, *e. g.*, a red, may be indirect, mediate, *i. e.*, through a word; nor should we call Ebbinghaus's material necessarily "conceptual" (as the writer does) but simply complex and variable: it involves several memories, but not necessarily classifications. An eye-ear-memory *may* be direct and immediate. We agree that these pioneer experiments give us functional rather than structural, existential, analytic results. (c) We take issue with the statement that the incentives to memorial transformations are always unconscious (490). In Chapter III, we bring a case in which the conscious filling of the memory interval affects the fidelity of the memory.

[1] There is an evident influence of this trope on the creation of the 'idea' in Humian psychology. *Apropos* of this, A. Frazer (*Amer. Jour. of Psych.*, IV, pp. 230, ff.) has called attention to the important influence of visualization on the construction of the psychologies of Hobbes, Locke, Berkeley and Hume. He concludes that 'idea' for these men connoted the visual image of the memory.

full description of these phenomena. They differ mainly, on the physiological side, in a more or less remote connection with excitation of the sense organs. Positive and negative after-images receive due attention in connection with theories of vision; abnormalities of the imaging capacity, as phantoms, hallucinations and illusions come under the direct care of the mental pathologist;[1] the memory after-image seems to be a special case under memory images proper, whose scanty literature calls for new investigations.

As the psychology of sensation and perception comes before the treatment of the more involved data of mind, so memory must be reduced to its lowest terms before its contents will easily submit to analysis. There is consolation here, as elsewhere, in working among the more elementary processes: the beginning may be more than a beginning, for the simple is sure to betray something of the nature of the complex, and thus the full analysis of the latter the more quickly follows. Psychology has often been asked to justify herself against the charge that she analyzes out 'mind' and only juggles with the inert remnants; but she is firm in the belief that careful analysis is the one initial procedure with complex processes whose outcome the history of science guarantees. The problem of the fidelity of the image is peculiarly dependent upon simple contents which are unequivocally related to definite peripheral excitations, since the character of the image is ascertained by its comparison with an external stimulus. In other words, we face a psychological problem on the assumption of a definite relation between stimulus and sensation. The uniqueness of the problem consists in the fact that a peripherally aroused sensation is here compared with one centrally aroused, instead of with another peripheral sensation.[2]

Before proceeding with an account of special investigation two preliminary questions confront us: (1) the relation of the memory image to perception, and (2) the function of the image in the life of the organism.

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[1] As Burnham points out (*Amer. Jour. of Psych.*, II, p. 456) there is close connection between the normal phenomena of memory and its pathological manifestations. It is not essential for our purpose, however, to discuss the pathological side of memory. The literature, though recent, is already bulky. But a theory of the image and its physiological substrate has to look very carefully not only into the direct disturbances of memory but also into the interferences in perception caused by various forms of aphasia.

[2] The terms "peripherally" and "centrally aroused sensations" are, of course, not to be confounded with Spencer's classification of sensations and emotions into "peripherally" and "centrally initiated feelings."

(1) It is quite evident that all developed[1] perception involves the past experience of the individual.[2] It is equally evident that not all perception involves a memory image. Where the image appears we have to determine.

The attempt has been made to base perception upon association aroused by external stimulation. Spencer, *e. g.*, includes under association the assimilation of past experiences to a new one of a similar kind (*l. c.*). Now it may well be that every central excitation leaves its record (in what way we do not know) in the brain, at least for a time, but this is quite different from the assumption that past events necessarily appear in consciousness, according to associational or other laws, when a similar present event occurs. Exploration of the perceptive consciousness, at least, fails to return evidence of such appearances, except under certain rather exceptional conditions. It is conceded, of course, that a perception is often a direct incentive to the arousal of memory images, but it is not clear that the perception is conditioned upon such arousal. Even recognition, which is psychologically a degree more complex than mere perception (or cognition, as it is often termed in distinction from recognition), need not involve 'reproduction,' as we have tried to show. Whether direct recognition be referred to a "quality of knownness" (Hoeffding), or to a unique feeling of recognition (Bourdon and Washburn), or to a "fringe of tendency" (James, *Psych.* II, 674), or is further analyzed into a mood, *plus* the power to excite central areas[3]

[1] Memory as a function of organic matter would figure in all instinctive and habituated response to stimulation; but we are not here concerned with this conception of memory (*cf.* Hering: "Memory as a Function of Organic Matter").

[2] Wundt says (*H. & A. Psych.*, p. 347, trans.): "Memory of some kind is involved in the cognition of an impression; memory of a definite kind in its recognition."

[3] The meaning of Kuelpe's phrase "in der besonderen central erregenden Wirksamkeit" (p. 178) is a little doubtful. It can hardly mean that an object is known because of a potentiality to attract excitation at the center (*cf.* Hoeffding's *Vorstellungs-potentialität*). The 'knownness' must be paralleled by some aspect of central excitation itself and not by a mere capacity. Perhaps the 'effectiveness' consists in an incipient re-excitation of certain centers. This is supported by the sentence a little further on (p. 178): "zu specielleren Urtheilen pflegt es bei diesem unmittelbaren Wiedererkennen nicht zu kommen, gewöhnlich wird bloss der Name 'bekannt' sofort reproducirt." We need not, however, assume, as Dr. Washburn seems to demand (*l. c.*, p. 270), that, the word 'known' is mediately reproduced through precedent conscious processes. It is conceivably sufficient that the repeated stimulus may itself immediately call up the word. It is not, however, our experience that *any* verbal impulse necessarily attaches to the 'familiar.' It seems to be often replaced by a general psychophysical attitude towards the known object. It is difficult to make this more explicit, but very probably the attitude is to be explained

(Kuelpe), the necessity of reproduction may be avoided. If reproduction is still urged in the form of 'dark images' (Wundt, Hoeffding and Lehmann), which introspection does not reveal, the *onus probandi* seems to fall on those who press the hypothesis of effective subconscious imagery.

No stimulus to sensation comes as entirely new to the organism: in other words, every *conscious* excitation, at least, awakens some reaction. From the side of consciousness, this means that everything goes together somehow in the individual's experience, *i. e.*, has a meaning; from the side of general nervous functioning we may say that every excitation that reaches the cortical centers disturbs a definite cortical area. The extent and nature of the excitation condition the resulting consciousness. The meaning involved we call cognition, recognition, train of thought, logical thought, etc. Now the place where the memory image appears, and the part it plays in contributing to meaning, are important. If we were to give a progressive series of the simpler types of meaning it would run something like this:[1]

I. Cognition or simple perception. No associations necessary. A minimum of meaning. (Wundt calls this assimilation, or simultaneous association, *i. e.*, fusion of sense impression and memory image, *plus* feeling of cognition; Spencer, association.) No image discoverable through introspection.

II. Recognition. A. Direct. i. Without interest. Taken-for-granted stage. Well-worn environment. A general feeling of comfort and security. Approaches *I.* No image.

ii. With interest (active or passive attention): object stands out from environment. Only association is verbal 'known,' which may be replaced by motor impulses. (Hoeffding finds 'quality of knownness;' Lehmann and Wundt, 'dark images;' Kuelpe, a mood *plus* tendency to central excitation; Ward, an assimilation process; Washburn, an unanalyzable feeling of recognition.) No image.

iii. Enforced (extrinsic) interest (active attention), *e. g.*, simple recognition under experimental conditions. Judgments 'like' and 'different' follow. Image not necessary.

iiii. Direct Recall: Memory in the narrow sense (Bradley, v. infra); 'pure' memory (Bergson, v. infra). A definite past, with subordination or exclusion of the present. Image essential.

B. Mediate. i. Through auxiliary ideas or other motives to recognition; *e. g.*, person recognized from description. May be image.

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by definite impulses to movement. Since familiarity differs in degree rather than in kind, the same motor reaction would be interpreted as object-known for a great variety of stimuli.

[1] This, of course, is not, in any sense, a genetic scheme.

ii. Conscious comparison of object and image. Image necessary.

This classification, though tentative, may serve to indicate the direction of increasing complexity of meaning which the simpler processes—those closely allied to sensory stimulation—exhibit. No hard and fast lines can be drawn between the various rubrics, and this indicates the continuity of the series.

The classification suggested will be further substantiated if we find that it agrees with the rationale of the development of the memory image. This brings us to our second point, and we have to ask what is the genetic significance of the image.

(2) If we take the biological point of view, it seems altogether probable that the memory image was a comparatively late acquirement for the organism. A command of consciousness through active attention, that should abstract from the pressure of the immediate environment and hold an isolated sensation-complex, aroused by central excitation, is the prerequisite of the image. A highly complex nervous apparatus seems necessarily involved.[1] The primary use of the image, we surmise, was to carry the organism beyond the limits of the immediate environment and to assist it in foreseeing and providing for the 'future.' Its function seems, then, to have been a prophetic one; it was a means to what we may term *remote adaptation*. The capacity to image is a prerequisite for a future. The extension of temporal and spatial relations has been immensely facilitated by excursions of consciousness beyond direct perception. In fact, the past and the possible (the not-yet), essentials for a developed time consciousness,[2] must have waited upon the power to abstract from the present. The mere presence of an image does not, of course, explain the complete elaboration of times. But when once the capacity for independent imagery has been acquired, the stress of existence will inform the image with significance.

The significance will, undoubtedly, be vague for a time. The image will mean a situation which does not belong to the one immediately presented; its temporal situation will still be

[1] The contention that some of the higher animals, *e.g.*, dogs, dream, does not seem improbable if we consider dreaming as one of the earliest—perhaps the earliest—appearance of the image. Oblivion to external stimulus might well be the prime condition for full consciousness of events not connected with perception. The pressure of the senses during waking life makes a practical demand on the attention which leaves little chance for central excitation to hold consciousness in its full right. It is indeed only at a comparatively adult stage that man performs the feat of total abstraction from the present.

[2] We do not, of course, mean mere temporal succession, which exists long before the differentiation of times past, present and future. *Cf.* Stern: Die psychische Präzenzzeit. *Zeitsch. für Psych.*, XIII, 325.

unfixed. Later, its extreme importance will attract the attention, and thus it will be reacted upon. As an element in action, it will become more and more teleological; it will become the headlight of consciousness, pointing before to an experience which is to follow, and which must be provided against. Thus two things are important in determining its setting: (1) it must be joined with the motor mechanism, and (2) it must be found to be a term x in a series starting from a present a; *i. e.*, it must be brought, in a twofold way, into connection with immediate perception.

The past, being less important than the future, must have been known, as such, later. Still, the future having been once created through the pressure for survival, the past would soon follow. A different connection with the present, would change the tense. Strangely enough, the past seems to have been more the fruit of leisure and idleness than the future. There is an instructive analogy among the earlier forms of civilization, where the historian is a much less important personage than the prophet, the soothsayer and the seer. Even for us the function of history is apt to be rather oracular than reminiscent.

Thus the general function of the image is analogous to binocular vision and binaural audition. The image does for temporal orientation what two eyes and two ears do for space perception. It adds perspective in time; these provide perspective in space. The former gives the distant in time from 'now;' the latter the distant in space from 'here.'

The necessities of life, however, must have demanded a suitable reaction upon environment long before images appeared. Wundt contends that the definite reaction upon food stimulus seen in the lower forms of life is to be explained "on the assumption that inherited organization determines the correlation of pleasurably toned sensations with certain sense-impressions, and that these sensations are connected with the movements subserving nutrition" (*H. & A. Psych.*, p. 348, trans.). This consciousness he calls cognition. Even recognition, which Wundt connects with "memory of a definite kind" (*op. cit.*, p. 347) and ascribes to the higher animals, might precede the power for independent images. This is borne out by the well-known fact that recognition is often possible when 'reproduction' fails. This accounts for our confidence when we say, *e. g.*, "I don't recall his face, but I should know him if I saw him." Similarly, in learning a language, many words absolutely refuse to be recalled which are recognized on sight. It is a doubtful explanation to say that the sight of the word is only a better incentive to its recall than is otherwise obtainable. How can it be an incentive until the word is first known and

its meaning adumbrated? And after the word is known, what is the need of an incentive? Again, Galton says (*Inquiries*, p. 97): "the visualizing and the identifying (recognitive) powers are by no means necessarily combined." And Ward points out (Art. "Assimilation and Association." *Mind*, N. S. II and III) that assimilation is prior to association and quite distinct from it. He argues that true memory is not involved in the former process, but arises only through association, which presupposes the connection of A and B by apperception in order to a recovery of the memory *b* through the recurrence of A. He holds that such apperceptive connection could appear only at a late stage of development. F. H. Bradley, in a recent article on Memory and Inference (*Mind*, Apl., 1899, pp. 145 ff.), remarks that "to know the past or future as such is a hard and late achievement of the mind, for it implies an enormous degradation of the present. . . . . Past and future do not and cannot exist for us until reality appears as a series in which the present has sunk and has become but one member among others." He continues by affirming that the emergence of a past and a future marks the line between the animal and the human mind.[1] The animal has "no world sundered from the world of its immediate practical interest, and to take an immediate practical interest in the past as past is surely not possible." (1) Like most attempts at fixing landmarks in genetic psychology, Mr. Bradley's is balked by too great preciseness. Lacking very definite data, psychology will hardly be satisfied at this day by a proposal to set off sharply the human from the animal mind by any broad functional activity, such as 'reason' or 'memory.' In this case it seems better to leave—until the *experimentum crucis* is made—the advent of the image more indeterminate, but to insist on its recentness. (2) As to the impossibility of an animal's "practical interest in the past," we repeat our suggestion that it is adaptation which attracts the first practical interest in the image. That the image should stand out *at all* from the 'present,' may, in part, be laid to the incompatibility of the 'perception' and the 'image,' as Mr. Bradley suggests.[2] But it is possible, also, that the image, considered apart from its proper function, as simply conscious event, may be quite different in quality from those sense impressions which mean for the animal immediate or present

[1] This line of demarcation was also suggested in 1886 by Ch. Richet; *Rev. philos.*, XXI, 587.

[2] Mr. Bradley's account of the genesis of memory seems to us to fail because it leaves out of regard feeling and volition. It is pre-eminently true of the simple mind that it learns by doing. No abstract consideration of associational series of ideas will account adequately for the development and extension of consciousness.

'reality.' May not the close relation between peripherally and centrally excited sensations be explained by similarity of function? A book before me now and remembered from yesterday is one book, whether perceived or imaged. The perception and the image mean for me one and the same object. But if we grant a qualitative difference[1] between them, we have an argument to add to Mr. Bradley's argument from incompatibility.

There is to be noted in this connection a recent monograph by E. L. Thorndike, on "Animal Intelligence." On the basis of experiments with cats, dogs and chicks, the author concludes that these animals are devoid of 'reason,' inference, and comparison, but are capable of forming associations; not associations of ideas, necessarily, but associations of sense impressions with impulses to activity. He finds no proof of the existence of 'free ideas,' 'representations,' or 'memory images,' and raises a doubt whether these appear at this level of animal intelligence. If representations are already present, he maintains that they are confined to specific and narrow practical lines and are revived on "the spur of immediate practical advantage" (as in obtaining food), *i. e.*, they serve primarily as means to previsory adaptation.

The late appearance of 'representations' is again supported by Bethe's work on ants and bees (Pflüger's Archiv, LXX, p. 15). This author makes the mistake of assuming a memory image as a *sine qua non* for recognition. However, he finds no evidence of recognition of any sort in his insects, and even intimates that consciousness may be entirely lacking to all invertebrates.

These two monographs, and a few others of the same tenor,

[1] There seems to us to be some introspective evidence for this qualitative difference; this above the vast differences in intensive, spatial and temporal characteristics. Kuelpe, who has taken up the analysis of imagery where Fechner left it off, emphasizes the latter discrepancies and, though he holds to a qualitative likeness, admits that this is only an *apparent* likeness, *i. e.*, "a relation of contents in which they [centrally and peripherally excited sensations] evoke the same judgment." We are inclined to go further, and to say that the two when considered apart from the "judgments which they evoke" possess quite different qualitative systems. The fact that experience demands a superposition of the two systems explains their apparent likeness and also the occasional confusion of perception and memory. It is moreover conceivable that the different nervous elements, central and peripheral, involved in the two cases should occasion a qualitative difference in consciousness. [*Cf.* H. Ebbinghaus's distinction (*Grundzüge der Psych.*, I, 167) between *Empfindung* and *Vorstellung*. Unfortunately, we have so far (erster Halbband) only the author's bare classification of mental elements, and do not yet know the precise import of this distinction].

are infusing a healthy tone of scepticism into comparative psychology. They make the very recent appearance of the more complex processes—inference, 'reason,' free ideas, images of the memory—exceedingly probable.

Contact with surroundings, harmful and advantageous, must have called for early recognition, as we have indicated. Well-known stimuli would bring pleasure or pain, and hence would be courted or avoided;[1] new stimuli would be generally avoided. As the unexperienced had not been necessary for life, the organism could afford to shun the new. Thus cognition or simple recognition would govern reaction toward the immediate environment, and only a later and more complex stage would demand conscious previsory adaptation.[2] This stage would be the longer delayed because instinctive reactions are reinforced among some of the higher animals by a motor habit, set up through the individual's experience, which seems to mediate recognition without the addition of memory images. M. Bergson (*Rev. philos.*, XLI, 225 and 380) has laid stress on this

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[1] The statement that the familiar is pleasant plainly needs limitation. The fact that the baneful as well as the useful recurs constantly in the individual's life is sufficient to guarantee that not all 'acquaintances' will be 'friends.'

[2] A genetic account of memory radically different from the one in the text is given by Professor J. M. Baldwin in *Mental Development in the Child and the Race*. Imageful memory is here accredited to most submammalian forms, but true recognition only to a very late period of development (pp. 319 f.). In the earlier, "simple memory" type are lacking "the finer motor, synthetic adjustments of the attention which by their variations constitute recognition." To us, the isolation of the image has seemed the difficult feat for consciousness, involving a nice control of the attention; while the 'familiarity' attaching to recognition was much the same for all such contents, and was easily provided for by a ready reception into the total consciousness and the peculiar motor reactions set into operation.

It is to be noted that the author has also called attention to the relation of the image to adaptation: he says (p. 319), "creatures which have in them the faculty of anticipating experiences, both pleasurable and painful, by the recall of memory pictures in something of the original setting, and which can, in consequence, anticipate the actual experiences to secure or avoid them by an adapted reaction, are most fit for natural selection." Our criticism of this position has been that the image, as simply a sensation aroused directly in the central organ, *may* assume one of several functions, anticipatory, memorial, imaginative or schematic. The storm and stress of existence point to this order as the natural one: anticipation, especially, seems the most elementary function of imagery, and not a mental product recast from the mould of pure memory.

Another explanation of the efficiency of memory images in aiding adaptation regards these as "idées forces," and demands that they be considered along with the physiological mechanics of memory. See Alf. Fouillée; "La survivance et la sélection des idées dans la mémoire;" *Rev. des deux mondes*, 1885, May–June, p. 359, and elsewhere.

type of motor memory, and gives as illustrations the dog's 'recognition' of his returned master, and with us the learning of a thing 'by heart.' This memory he sets over against imageful or 'pure' memory, whose rise he places at a later date. Whether or not an animal's definite and peculiar reaction to his master can justly be termed recognition in the usual sense, it seems much easier to err in ascribing it to the power of recollection *through images* than in limiting it to obvious motor concomitants *plus* strongly toned feelings. It seems, then, a useless abrogation of the law of parsimony to attribute to most of the lower forms of animal consciousness a power of abstraction sufficient to image the past or the future. If utility explains the existence of the image, as intimated above, one sees the close connection between memory and imagination. So long as a rough-and-ready attitude toward the world suffices for survival, images will not appear. It will only be after the non-present has been thrown up against the background of perception that its contents will be conceived as possibility, and then as warning,—and thence the way to prophetic adaptation is short.[1] Instinct aroused by 'familiar' stimuli comes to be superseded by conscious prevision. This prevision, though closely allied to imagination, is not to be confused with it. It is expectation, rather than imagination. In expectation, the image is set over against the present: in imagination, it drives out and supersedes it.

The acquirement of language, spoken and written, has made an essential change in the modes of memory. Visual and auditory images of things have been, through it, largely replaced by verbal memories. Written language, especially, has relieved imageful memory of a great burden. Traditions of the tribe handed down for generations are supplanted by histories: descriptive writings take the place of camp-fire narration. Language improves on images of the memory because it stereotypes. Among civilized peoples, old memory types persist but are of small value, in general. Indeed, few people are conscious of the memory type which they represent, although linguistic memory preserves the preference for visual, auditory or motor retention. The reduction of adaptation to a set of rules destroys largely the necessity for encasing the past in images kept for reference in preparing for future needs.

Still, the memory image has not entirely lost its function.

[1] An intermediate stage in this process is furnished by the memory after-image, which is immediately dependent on its peripheral excitation, and soon vanishes, but is a step toward the differentiation of the present from the non-present. For the time-limits of the memory after-image under distraction, see A. H. Daniels (*Amer. Journal of Psy.*, VI, p. 558).

Retention through the centers for vision, audition and movement often leads to imagery. Language, because of its fixity, requires to be supplemented by images which hold the concrete event for future use. Galton (*op. cit.*) makes some interesting observations on this point. He finds the visual imaging power very great in young children and in some wild races as, *e. g.*, the Bushmen and Eskimos, and remarks that "language and book-learning certainly tend to dull it," and that "our bookish and wordy education tends to repress this valuable gift of nature." He speaks of the French as facile visualizers and says: "the peculiar ability they show in prearranging ceremonials and fêtes of all kinds, and their undoubted genius for tactics and strategy, show that they are able to foresee effects with unusual clearness." He finds that "the faculty is undoubtedly useful in a high degree to inventive mechanicians, and the great majority whom I have questioned," he says, "have spoken of their powers as very considerable." And again: "a visual image is the most perfect form of mental representation whereever the shape, position and relations of objects in space, are concerned. It is of importance in every handicraft or profession where design is required. The best workmen are those who visualize the whole of what they propose to do before they take a tool in their hands." Galton does not distinguish sharply between the faithful memory image and the image of phantasy. His illustrations show how the former merges into the latter. Indeed he says (p. 173): "recollections need not be combined like mosaic work: they may be blended on the principle of composite portraiture. I suspect that the phantasmagoria may be in some part due to blended memories."

The whole realm of literature and fine arts, so far as it is the creation of phantasy, shows the memory image at sport; the phantasy stands to the reproductive image as play to work;[1] and, like these, the memory and phantasy images represent the activity of one and the same function. Memory, continually dropping and picking up its threads and dyeing them anew, weaves the bizarre fabric of the imagination. It takes its cue from utility, and here necessity truly is "the mother of invention." Compelled to utilize experience as a lesson for the future, the imaging tendency survives its most imperative need and loses itself in the vagaries of phantasy.

Briefly, then, our view concerning the lineage of the memory image is as follows. The earliest conscious reaction upon environment was provided by intimate connection of pleasurably-toned sensations with reactions appropriate for nutrition. Such

[1] Quite a different relation from the early prophetic and retrospective imageries.

reactions developed into complex instinctive actions in presence of both pleasurable and unpleasurable perceptions. Next, the distinction between the familiar and the strange (nascent recognition) appeared. As adaptation became too complicated and too delicate to be entrusted either to instinctive control or to response in face of critical stimulation, a discrimination between the present and the non-present arose with the appearance of general images. These images were excited in a variety of ways, and helped to govern action as peripheral stimulation—special and organic sensations—had done before. Special images set in a definite place in the 'future' and the 'past' came later, and mediated adjustment for special occasions. Simply as a part of the past the image has had little value, but as an index of the future its function has been important. With the rise of language, experience became conventionalized, and set rules replaced the less reliable images. These still persist, however, (1) where arrangements and previsions do not permit linguistic statement, and (2) as phantasy images.

CHAPTER III.

EXPERIMENTAL.

It is above all essential, in dealing with memorial imagery, to supply conditions which shall assure the presence of images. As we have before indicated, retention and even recognition do not themselves give such assurance except under certain definite conditions. It will be seen at once that there is a limited range of imagery from which to choose. Images of taste and smell are comparatively rare. Olfactory and gustatory memories usually reduce to peripherally 'reproduced' or to imaged puckers, smacks, swallowings, salivary excitations, inhalations, organic sensations, auxiliary ideas of space and time relations, and feelings. Smell and taste imagery proper is too scanty and too uncertain to turn to account in a preliminary study of imagery. There is an evident biological reason for the paucity of images from these two senses, in civilized man at least. Names, colors, general appearance, etc., have been of more service in the memory than direct images of taste and smell could have been. It is very probable, however, that in primitive conditions these had a much more important function. Haptical images, beside being vague and ill defined, offer peculiar difficulties. There is, in the first place, a strong liability of confusing images of the memory with sensations excited in the terminal organs. The sensory-motor connection is especially strong between muscular and tendinous images and

innervations. A concentration of attention on an imaged movement is pretty certain to become the adequate stimulus to peripherally initiated strain sensations. The difficulty of isolating 'muscular' images is shared by smells and more especially by tastes. Since the adequate stimuli to the last two senses are not definitely known, it often occurs that one is not sure whether one has a *bona fide* image or an actual excitation in the end organ. Of haptical images it may again be said that various factors—pressures, pains, temperatures, strains and joint-pulls—are so indissolubly interwoven that the isolation of any one sense image is well-nigh impossible. To this may be added the fact that skin sensations, because of their functional, external reference, are overgrown with visual associations.

Organic images elude so successfully the usual incentives to reproduction, and are so vague, as to put their employment out of the question.

There remain the two most highly developed special senses—audition and vision. Here we find a wide range of stimulus qualities and intensities, paralleled to some degree by a wealth of memorial imagery. Here, if anywhere, we ought to be able to isolate the image, to study its nature and function, and to determine its qualitative fidelity by close comparison with sensation.[1]

We have chosen visual imagery because it seemed to promise better material for moulding a satisfactory method, and because it delivered us from various technical difficulties which audition presents. We have not attempted much more than an exploration and scrutiny of methods, and a prolusion for subsequent work. We may be allowed to remark that a more systematic investigation than we have been able to make is now in progress in the department of acoustics in this laboratory.

The work with visual images extended over colors and brightnesses.[2] Brightnesses were found to offer the simplest conditions,[3] and were pressed farthest by various methods.

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[1] The inexact distinction 'sensation' and 'image' is employed simply as a matter of convenience. It avoids a long circumlocution, and sets off 'image' from memory in general. Kuelpe's distinction of "peripherally" and "centrally excited sensations" seems the clearest.

[2] Additional experiments on memory for visual form are not yet published.

[3] It hardly need be said that the reason for discussing only images of the various senses is their relative simplicity. Here one has the best opportunity for instituting a direct comparison between an image and its corresponding 'sensation.' As one retreats from sensuous 're-excitations' one gets more and more on the border line between memory and imagination, and into the realm of general mental imagery, that is, into the region where the temporal position of the image be-

Methods. As we have seen, investigations of the memory suggest two principal methods: reproduction and recognition, and two auxiliary ones: comparison and description. Since our work was largely methodological, it seemed best to exploit as many different paths of procedure as possible.

(a) *Description.* The least accurate and the least used experimental method is the method of description. Objects, colors, forms, sounds and events usually admit of verbal description. The experience may either be retained in verbal motor images which are reported directly, or in any of a half-dozen other memories which are translated into descriptive terms for the report. A more primitive and direct mode of description, which lies in the direction of reproduction, is the gesticulatory and mimetic. Here a situation is associated with certain motor reactions, and these reactions when renewed serve to recall the situation to the narrator's audience. As we intimated above (p. 10), naming gives a clumsy classification of experience, inasmuch as the same noun or adjective may cover a variety of slightly different experiences which have not enough individual importance to attract separate names. In other words, the indirect is not adequate to the direct sensible discrimination. Külpe draws attention to this fact when he says that association by similarity may often be reduced to reproduction of a common name. As a case in point, Lehmann observes that the German language has only five common names for grays. This out of seven hundred brightness qualities. The case with tones is analogous. We may say, in general, that when small differences are to be looked for, oral description is impossible.

(b) *Recognition* we have seen to be a fruitful memory method. The caveat that was lodged against it in connection with the work of Lehmann and Wolfe has, however, made us cautious here. If 'reproduction' of an experience through an image is not the only modus for memory, the method of recognition is not likely to disclose the fact. The very fact that recognition and reproduction reveal such different capacities for retention points to the evident truth that the image is not the sole vehicle of memory.

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comes indistinct or altogether lost. The 'mental image,' if it is to be distinguished from images of memory, expectation, and imagination, is properly the image unplaced in time. Such an image is normally the result of many similar experiences; *e. g.*, my image of a pin is, until I develop it, a pin image and nothing more: (*cf.* J. Philippe, *Rev. philos.*, XXII, 2. Thus, much of experience gets its personal, episodal side worn off, and becomes 'common mental property.' Whether an image assumes the function of memory, expectation or imagination, or remains only a 'mental image,' depends, of course, largely on the context, and this is as rich and varied as mind itself.

(c) *Reproduction* by itself is limited in its range of application. In the first place, the reproduction (except in the case of muscular, including verbal motor, sensations) has always to come through another sense department than that to which the image belongs; *e. g.*, color, brightness and form through the hand and arm (mixing and drawing), tones through the throat. The reproduction of visual sensations has the further disadvantage that it takes time, and before completion direct recognition complicates the process. The same objection holds for the method of selection used by Baldwin and by Binet, though as a measure of memory capacity this method has value.

The foregoing criticism of the method of reproduction implies that the method covers indirect S. D. (report), as well as the immediate experience.[1] Taken in this way, it is at once seen how near the method comes to description. If, however, we mean by reproduction merely the unequivocal appearance of an image, we give the word a perfectly definite and legitimate signification. Taken thus, reproduction is quite indispensable to any work on images. It does not, however, give a complete method, and there still remains the task of getting at the image and recording it. This is the psychological problem which was stated in the beginning of the second chapter. The method is completed by a comparison of the image with some carefully chosen stimulus to which it is intimately related. It may be better to avoid entirely the ambiguous word reproduction in this connection, and to substitute the word 'recall,' to indicate that an image has been brought voluntarily into consciousness. The method by which it is educed and compared with a given sensation may then be termed the method of (d) *Recall and Comparison.* It differs from other methods (1) in scrutinizing the actual contents of memory, and (2) in making possible a direct comparison of image and sensation.

Apparatus. The Marbe adjustable color-mixer[2] was used. The mixer is run by an electric motor, and carries two intersecting discs of 11.5 cm. diameter. One of the two sectors is adjustable by means of a rack and pinion behind the disc, moving at right angles to it. The size of the adjustable sector is read off on a scale lying against the toothed rack. The ad-

[1] The distinction here between direct and indirect sensible discrimination might be brought out by the terms 'internal' and 'external reproduction,' or much better by reserving the word 'reproduction' for memory images: for mental processes which possess the function of direct reference to previous experience. The *expressing* of such experiences would then be 'productions,' as drawing, painting; or 'descriptions,' as talking, gesticulating: *i. e.*, either *direct* or *indirect* reports.

[2] For description of the apparatus v. *Centralb. für Physiol.*, VII, 811.

vantage of the arrangement is that one sector can be altered at will during rotation. In this way a continuous change of color is possible or, with a short interval for shifting, two successive stimuli can be given without introducing a space error.

Series I. The observer in our experiments sat before the disc at a distance of 2¼ meters. Exposure was made by lifting a black screen directly in front of the disc. In the first set of experiments the variable sector—60° to 100°—was White, and the other Blue, Red, Green or Black. The brightness or color stimulus r was exposed 5 sec., and after an interval—1 min. or 5 min. (in a few cases some days)—a second stimulus, either r_n (=r) or r_l or r_d, was given; r_l contained 5° more, and r_d 5° less of the white sector than r. We will call the first stimulus N, the second V. Just before the end of the memory interval the subject was asked whether he had a visual image of N. After V was exposed, the usual report, "same" or "different" (*i. e.*, "greater" or "less"), was passed. The object of the recall was to bring the image, if it persisted, into consciousness for comparison with V. Under the head of "images" the record was kept "good," "poor" or "lacking." "Good," as carefully explained to the observer, meant a definite visual image, clear and of a distinct quality, "poor" a vague, confused image, and "lacking" a failure of voluntary imageful recall of N. The experiments were performed in the daylight between 9 and 12 A. M., and a few between 3 and 4.30 P. M. Most of them were done with a clear sky; chance changes of illumination between any N and its V were sufficient cause for throwing out a record. The subjects were asked not to attend to N during the interval, and although no regulated distraction was afforded, introspective confessions indicate that it was not usually adverted to until the query as to the presence of an image was made. The subjects did not read or look at colors (except the very dull gray and buff tones of the room) during the memory interval. Their eyes, however, were kept open.

Four of my colleagues, Drs. Gamble (G) and Pillsbury (P) and Misses Dolson (D) and Burch (B)—all psychologists of some training—assisted as observers. A few results were also got with long intervals from five other students in the department (A., R., S., T., and Ti.).

In the year 1896-7, 600 results were obtained by this method; 500 with 1 min. intervals, 84 with 5 min. intervals, and the remainder with longer times.

In relating the arrangement of stimuli to the reports of the observers, three categories are possible, to wit: (1) objective and subjective agreement (C), *i. e.*, objectively equal stimuli are judged equal, greater greater and less less; (2) a memorial lightening (L), *i. e.*, a V=N is judged "darker," a V lighter

than N is judged "equal" or "darker;" and (3) a memorial darkening (D), *i. e.*, a V=N is judged "lighter," a V darker than N is judged "equal" or "lighter."

It will be seen that every deviation in judgment from stimulus magnitudes is a deviation of *at least* 5° of White. In some cases—as *e. g.*, equal judged darker or lighter—it may be much more. The results do not tell how much.

Table I shows the total results for the various subjects. Initials at the left indicate subjects; L, C, and D the categories above given; and the figures the number of experiments falling under each head.

TABLE I.

	L	C	D	SUM.
B	117	106	33	262
D	17	27	7	51
G	35	51	33	119
P	71	50	31	152
A. R. S. T. & TI.	11	4	1	16
Total Jdmts.	251	238	111	600

The most striking thing about the Table is the distribution of the L, C, and D cases. There are 13 more L than C cases, and more than twice as many L as D cases. Reducing the footings to per cents. we have:

L	C	D
41.9	39.7	18.4

Or, considering only the 'errors,' we find that 69.5% of these fall to the L side. This may be interpreted to mean that whatever stands in the memory for N has a tendency to change during the interval toward the light; *i. e.*, as compared with V, N becomes "too light" in the memory more often than it remains unchanged, and inclines to the light 2.3 times as often as it does to the dark.[1] Now, since a constant difference ($\Delta=5°$), which was found previously to be near the liminal value for our observers, was used, the results may be brought into a gen-

[1] An analogous case with tones—a rise in pitch through the memory—has been noted by Hirschberg (q. v.). Wolfe (*l. c.*, p. 556) holds that the reverse is true, *i. e.*, that a tone in memory is weakened and therefore lowered in pitch.

eral relation to those gained by the method of right and wrong cases.[1] With this method, if $\frac{r}{n} < 50\%$ there must be a constant error $> \Delta$. If we regard our C column footing (Table I) as giving the number of right cases $(\frac{r}{n})$, we find that its value is not only $< 50\%$, but that it is less than the footing of the L column (*i. e.*, $238 < 251$). We may therefore conclude that the constant error connected with the memory of N is considerably greater than the D used, namely 5°. More precisely what the value of the memory "error" is, the method does not, unfortunately, tell us. Even though the method were adequate, the number of cases is not sufficient for a strict interpretation by means of the probability curve.

It will be remarked that the judgments of *G* form an exception to the general tendency indicated by the Table. *G's* C-judgments are more frequent than the L or D ones, and these latter are approximately the same (35 and 33); *i. e.*, her errors are equally distributed in the two directions. Introspective notes made during the experiments, as well as results obtained later, furnish an explanation. *G* visualizes with great difficulty, but makes dexterous use of her verbal memories to cover the deficiency. If we add to this the fact that a large number of her reported images are general, that is, are 'mental' images instead of 'memory' images, we get a clue to the apparent anomaly of her results. Here is a case of what we spoke of earlier as the stereotyping effect of language. Verbal images when quite simple have little temptation to change, and when they do change it is not (except by accident) in a constant direction along a qualitative visual scale. *B* is a very facile visualizer and inclines but little to verbal or descriptive memory. *P* and *D* are fair visualizers and their verbal memories appear but little in the series. Of this we shall say more later.

Returning to the matter of the memory 'error,' we shall see that the tendency toward *L* judgments is also evident if the series is divided up according to stimuli used. See Table II.

The per cents. in the following Table must not, of course, be taken too seriously, since the whole series contains only 600 experiments. Still there is evidently a stronger tendency to lighten in the short-wave half of the spectrum (represented by Blue and Green) than at the Red end. Memory for Gray under these conditions seems to be only better than for Red.

The variable White sector alters, of course, the saturation as well as the illumination of the colors. That the change, due to the memorial factor, is, however, largely one of bright-

[1] The fact that Δ was sometimes omitted and N followed by V=N makes the procedure somewhat irregular. It will not, however, affect the general conclusion that we wish to draw.

TABLE II.

(W=60° to 100°.)

	L	L: SUM.	C	D	SUM.
Blue	90	48.4	68	28	186
Red	51	35.6	59	33	143
Green	45	44.1	29	28	102
Gray	65	38.4	82	22	169
Totals	251		238	111	600

ness is argued by the fact that the percentages under L fall so close together for the pure brightness values (grays) and the mixed values (colors). The exact amount of influence of the two factors could be determined only by a calculation of the brightness valences of the colors used. Spectral values would not apply to our papers; and, since the method does not give a maximal, but only a minimal value for the memorial alteration, the valences would be of little use. We will leave, then, the minor, saturation factor, and concern ourselves only with the bearing of memory on estimations of brightness.

Effect of Length of Memory Interval. Having found that the memory contents (we have still to ask what this includes) changes during the memory interval, we have now to inquire whether the change produced is a function of time elapsed. This inquiry, it is to be noted, differs from the inquiry of Ebbinghaus and others (*v.* Chapter I) into the available *amount* of memory material at any given time; that is to say, the relation of memory to obliviscence.

M. Philippe[1] (*Rev. philos.*, XXII, 5) concludes that "mental images" change in the following ways: (1) by fading, elements are dropped or confused; (2) to new images, but remain clear; and (3) toward a type.[2] This list of possibilities will serve our present purpose.[3] Leaving out the first

[1] The method used follows Binet, and involves the various disadvantages of description.

[2] F. Kennedy (*v. supra*) gives a similar list, *viz.*, fading, quantitative and qualitative change.

[3] J. H. Leuba found a similar thing with brightnesses (*Amer. Jour. of Psych.*, V, 370): dark and light images tend toward a medium value. Concerning his method it is to be remarked that (1) the existence of the image was not assured, (2) the standard stimulus was either always in sight or only called for at irregular intervals, (3) sensory after-

rubric, which presupposes a more complex contents than ours, we may ask if the qualitative change in the memory contents, whether toward a type or not, is a function of the time interval.

The following Table III gives the three classes of judgments by intervals elapsing between N and V.

TABLE III.

INT.	L		C		D		SUM.
1′	196	39.2%	205	41.0%	99	19.8%	500
5′	44	52.4%	29	34.5%	11	13.1%	84
2 days	5	62.5%	2	25.0%	1	12.5%	8
7 days	6	75.0%	2	25.0%	–	——	8
Total	251		238		111		600

The figures indicate that the tendency of the memory to lighten increases with the length of the interval. The results, however, demand further support.

Relation of Judments to Images Reported. As we stated earlier (p. 29), a record of images was kept along with the reports of likeness and difference, the subject attempting each time to bring to mind the proper image of N just before V was presented. The only exception to this was in the case of a few (17) early experiments with B.

The following Table gives the number of total experiments under each head, the number of 'good' images and the sum of 'good' + 'poor' images.

We may conclude from this showing: (1) that it is possible for some time afterward to recall a very simple visual impression by means of a visual image. In our series visual images of some kind were obtained in $\frac{5}{6}$ of all the experiments; (2) that after an interval of 5 minutes imageful recall is better—both for good and poor images—than after one of 1 minute.[1] The longer intervals are scarcely comparable with these be-

images were confessedly disturbing, and (4) the result just spoken of is probably to be referred to stimulation within the memory interval, since one image (if present) held over for several successive intensities. The indication of a general law for sense memory is extremely questionable.

[1] This is not in agreement with Lehmann (*Studien*, V, 153), who concluded that the visual memory image is of little value in recognition after one minute.

TABLE IV.

	L	Rel. of Ims. to Exps.	C	Rel. of Ims. to Exps.	D	Rel. of Ims. to Exps.	SUM.	Rel. of Ims. to Exps.
1′ INT.								
Exps.	196		205		99		500	
Good Ims.	121	61.7	118	57.5	51	51.5	290	58%
All Ims.	169	86.2	166	80.9	80	80.8	415	83%
5′ INT.								
Exps.	44		29		11		84	
Good Ims.	34	77.3	19	65.5	4	36.3	57	68%
All Ims.	37	84.1	26	89.6	8	72.7	71	84½%
2 & 7 DAYS.								
Exps.	11		4		1		16	
Good Ims.	4	36.3	4	100			8	50%
All Ims.	8	72.7	4	100	1	100	13	81%
TOTALS.								
Exps.	251		238		111		600	
Good Ims.	159	63.3	141	59.2	55	49.5	355	59%
All Ims.	214	85.2	196	82.3	89	80.2	499	83%

cause they were used by different observers, less trained and less reliable in their introspective reports. (3) It is to be noted, finally, that the largest percentage of L judgments is accompanied by images both good and poor, the C judgments next, and the D judgment next. That is, not only is there a tendency in the memory to lighten, but the tendency is strongest where the memory is a visual image. It is not, however, apparent that the change of the image is the sole cause for the lack of memorial fidelity. Our introspective evidence which is to follow will perhaps aid us here.

Series II. We observed in connection with the modified Right and Wrong Cases method that since Δ did not always appear it was impossible to calculate the exact amount of the memory error: then, too, the time consumed in the longer intervals makes it difficult to get a sufficient body of results for the application of the law of probability. For these reasons, the following new method was tried. A standard disc[1] (black and white) was presented to the subject 5 secs., and at the close

[1]Apparatus and papers (Zimmermann) used same as in former series.

of the memory interval (1, 2, 3 or 5 mins.) a variable disc 30° lighter or darker than the standard (N ± 30)[1] was presented, and shifted (made darker or lighter) until subjective equality was reached. As before, the attempt to produce a visual image was always made. Our observers were Drs. Gamble (*G*) and Sharp (*S*), Miss Carter (*C*) and Mr. Kairiyama (*K*). All were trained in psychological work.

The following Table gives the results. Set I was done during the fall of '97; Set II the following winter. The first column gives the observers, the second the degrees of white in the standards, and the following columns the degrees of white in the V's III N. The various values for V represent the average of four results.

TABLE V.

	Set I.						Set II.				
	N.	1′	2′	3′	5′		N.	1′	2′	3′	5′
K.	120	122.0	123.7	121.7	137.5	K.	120	124.5	122.2	123.0	118.6
	100	110.0	104.5	108.5	103.0		100	102.5	107.7	——	104.0
C.	120	121.5	123.2	124.5	113.2	C.	120	116.7	120.0	116.5	——
	100	97.2	97.2	102.7	100.2		100	107.0	103.0	97.0	——
G.	120	118.5	131.0	111.7	120.7	G.	120	120.7	122.7	120.0	122.2
	100	92.7	79.7	94.7	101.5		100	87.7	90.7	96.0	91.0
S.	120	118.5	116.5	119.5	125.7	S.	120	121.0	121.0	132.2	——
	100	102.5	101.0	104.0	103.5		100	98.2	103.0	100.0	——

The objective values for N were wholly unknown to the observers, who invariably supposed that several (5 to 8) values were being given. If they had detected that there were but two, their images would have become stereotyped after a few trials, and instead of reviving each time the immediately preceding sensation alone, the whole series would have contributed to the memory stock. This summation process is, in fact, impossible to be rid of entirely, however long the series of stimuli, and may as well be faced wherever qualitative memory work is attempted. In truth, it also appears in various psychophysical measurement methods; for example, in the methods of Average Error and Right and Wrong Cases, where the same stimuli are given over and over again. Two results follow. The first is indicated by Paneth (*sup.*, p. 4), who thinks that a thing may be remembered by its place in a series—by its relation to similar things—rather than in its own right. Now the more often a thing is experienced the more definite does its *locale* become. It is related just so and so to its neighbors. It is a gray (say) which stands in a certain relation to other lighter and darker

[1] The direction alternated.

grays. Even where, in other work, a long series of grays was used, there was a well-marked tendency in some subjects to put an impression immediately under a verbal rubric, or to retain the visual image by setting it directly into a line of grays.[1] The second result of this tendency is to complicate the memory process. The seventh term of a series in which a given stimulus is presented over and over again cannot be taken into the mental economy on just the same basis that the earlier terms are: the repetition itself has caused a bias. It seems to be just this kind of a bias which is at the bottom of various "time errors;" it has never been shown, so far as we know, that these are, or are not, connected with a memory image. It seems altogether probable that a stimulus affects the nervous system differently, even the first and second times, without any reference to an image.[2] This difference may then be simply emphasized, if the stimulus is given over and over again.

The method used in Series II is a compromise between reproduction and recognition. There is 'objective' reproduction—

[1] Cattell and Fullerton (*loc. cit.*, p. 149) make a similar observation.

[2] Kuelpe contends (p. 213) that the direction of the 'time error' with successive stimuli should be constant if the error is due to the weakness of the memory image: but it is not; sometimes the second stimulus seems greater and sometimes less. For example, Fullerton and Cattell found that the second of two successively lifted weights—interval 1 sec.—was over estimated (also Lehmann, Starke and Merkel), while with lights (same interval) the second was underestimated. With larger intervals only the probable and not the constant error is given. No satisfactory explanation is offered. A. J. Hamlin (*Am. Jour. of Psych.*, VIII, p. 53) found a tendency to over estimate the second stimulus when a memory image was present. Wolfe and v. Tschisch agree that tones weaken in memory. Leuba's results have already been noted. A. Wreschner (*Dritter Intern. Cong. für Psychol.*, p. 204, and *Methodol. Beitr. z. psychophys. Messungen*, 1898) calls attention to the memorial factor in the time error and says that (with weights) high intensities weaken in the memory, low intensities are strengthened, and a certain moderate intensity remains unchanged. He notes (*Beiträge*, p. 174) that *fading* of the image does not necessarily mean *diminishing:* a very important distinction. Like Leuba he finds a tendency for the image to approximate a medium intensity; this accounts for both the positive and the negative errors.

W's contention (p. 173) that memory plays different rôles in sensible discrimination (where the first sensation passes over almost immediately into the second), and in longer time-intervals, receives confirmation in our Series III, below, which indicates that different rules hold for short intervals—2″—6″—and for longer ones. We can, at least, say that the longer times afford greater range in memory materials. For the short times (S. D.), it does not seem to us that W. is entirely successful in substituting conscious memory (the image) for the physiological explanations of the time error offered by Fechner (*El. der Psychophysik*, II, p. 142) and by Müller and Schumann (*Pfl. Archiv.*, XLV, pp. 37 ff.). At the same time, he has contributed much toward a definite statement of the complex conditions under which this error appears.

production—inasmuch as the making of the stimulus is done under the subject's eyes. Instead of allowing him to mix his colors or grays, they are made for him. There is recognition, inasmuch as he pronounces on the identity of two impressions. It comes very near Baldwin's method of selection, too, since a series (unbroken in this case) is given and the subject selects the 'right' stimulus. It includes, not only a judgment of likeness, but also several judgments of difference.

For our use, the method has two points to commend it. (1) It shows the range of the memory 'error,' and (2) it gives a definite approach to a given stimulus from two opposite directions, thus improving on ordinary reproduction. On the other hand, its imperfections are not to be slurred. There is introduced, first, a source of error in the rate of change of the gray. The white sector was always adjusted by one person, the experimenter, who controlled his rate by means of metronome beats, thus minimizing constant and accidental errors of speed. A clock-work arrangement for adjusting the white sector was planned but could not be procured in time for use. The expectation error was eliminated and successive contrasts balanced by change of direction ($N \pm 30°$). Expectation would, however, tend to obscure a constant memory error; *e. g.*, a change of $+10°$ W. in the memory would require a movement of $30°+10°$ in one direction and $30°-10°$ in the other, while expectation would tend to reduce the difference. Finally, the employment of the memory image is rendered difficult by the presentation of a long series of V from which to choose. By the time the proper gray is reached, the imaged is obscured, though it was perfectly distinct at the close of the memory interval.

The large mean variation got from our limited number of experiments throws doubt upon the practical value of the method. This was as follows for all intervals:

K, 4.4°; *C*, 6.1°; *G*, 7.5°; *S*, 4.0°.

Thus the *m. v.* in the cases of *C* and *G* exceeds the minimal amount of memory increment (5°) found in Series I.

Individual Differences. Only in the case of *K* is there shown in Series II a constant and decided lightening in the memory. The result is noteworthy. A gray of 120° W. is judged to be equal (after the intervals 1′, 2′, 3′ and 5′) to 123.2°, 123.0°, 122.4° and 128.0° and a gray of 100° W. to 106.2°, 106.1°, 108.5° and 103.5° respectively. This, in face of the levelling tendency of expectation, means a very positive tendency of the memory. It has already been remarked that *G* avoids visual memories. Introspective notes, accompanying the results here considered, confirm this. The grays were often held in memory by a verbal associate: *e. g.*, the observer found herself using the

terms "very dark," "medium dark," "medium," etc. These were used as genera, and several grays lying near together could be brought under each by further verbal qualification. Where an image was present in its own right before the second stimulus came, it was referred to verbal descriptions to test its validity and was judged 'right' or 'wrong.' The observer's capacity for visual images seemed entirely inadequate for the work in hand. These facts afford an explanation for *G's* large *m. v.* and for the lack of constancy in the direction of her errors. The distribution of her errors is very much the same as it is in Series I (*cf.* Table 1). Her scheme of names is undoubtedly responsible for the general underestimation of the 100° stimulus (Table V). *G* failed to discover traces of mood[1] in recognition of grays as 'like' or 'different.' There was, at times, a perception of strain, little localized, and of oppression and heat about the chest, when trying to recall, but these phenomena were rather connected with the attention than with recognition or reproduction itself. Finally: an unusual variation in the stimulus, as a purplish or yellowish hue, was emphasized and exaggerated during the interval, doubtless by verbal description.

C is slightly more visual than *G*, but her visual memory does not stand by itself. She reported her images to be patches of gray indefinite in outline. These were placed in front, to her left, or in the back of the head. Images were got by an effort: recollection was accompanied by strains in the back and chest. The strains worked upward and ended in the scalp. Diffused sensations from the trunk were prominent. If the effort produced an image, it was either accepted, or rejected as wrong. Like *G*, the observer used other criteria than visual images for her authoritative memory data. For *G's* verbal memory, *C* substituted freely organic sensations and feelings. She stated that gray cloths had interested her greatly on account of the strong affective tones which they produced. Light grays were extremely pleasant, dark grays unpleasant, some of them even ugly, and medium grays indifferent. The same feelings were produced by the gray discs, though repetition reduced them very much.[2] In the last half of Series II, *C* had seven general rubrics which corresponded to cloths. These 'generic' images it

[1] The circumstances were unfavorable for a "recognitory mood." Our experience is that this appears in complex, visual and aural situations, with a strong practical interest attaching. Smells and tastes, though comparatively simple, are generally rich in affection and are not, for that reason, lacking in mood. Experiment, on the other hand, deadens intrinsic interest and rapidly lessens mood.

[2] Light grays were recalled easiest, dark next, and medium with greatest difficulty. Thus is shown a direct relation between feeling and capacity for reproduction.

was which came up for approval with the effort. They do not depend on verbal associations so much as *G's* images do, but are permanent visual furniture, supported by a mass of associated situations (people met, *e. g.*) and affective coloring.

If we reckon qualitative fidelity of the memory in inverse ratio to the amount of deviation from the memory stimulus = N, we get for *C* and *G*, F_c: F_g = 2:1, *F* standing for fidelity and the figures for the two deviations—6° for *G*, and 3.15° for *C*. It does not need to be added that this is a measure of general functional memory, and not of the visual image. Even as indicating capacity, it would be a doubtful exponent of these memory types, in general, since individuals show such amazing variety in the combination of memories.

S has a more useful visual memory than *C* or *G*, but relies a good deal on verbal descriptions and other secondary criteria: *i. e.*, visual associations. There was detected no trace of mood in connection with her judgments and no organic or general adjuvants. The average deviation of the second from the memory stimulus is 2.92°. The Table (II) shows a slight tendency toward the light.

Leaving the general results, let us select those in which "good images" were reported. These stand in Table VI. K is not included, since practically all of his results fall within the above category (*v. sup.*).

TABLE VI.

SUBJECT.	NO. EXPS.	N	V
C	3	100	109.0
	3	120	129.0
G	8	100	97.7
	9	120	132.0
S	12	100	101.0
	14	120	123.0

The Table explains itself. *G's* one exception is readily understood by what has already been said. Her best images, even, were not much relied upon by herself. There is, however, quite a difference between the 97.7° and the corresponding values in the general Table (V).

There is in connection with Series I and II one further point which seems to us important.

It frequently occurred, with all the observers of both series, that a judgment was given with no hint of a comparison of two stimuli. Even where no active recollection was possible, no

vestige of an image surviving the interval, a decision came like a flash with the giving of the second stimulus.

By much questioning we found that the observer's confidence in the correctness of his decision was quite strong in such cases, but usually he was entirely at sea when asked how he made the judgment. There was no trace of a comparison, no trace of the coupling of sense with memory contents. The expression of sameness or difference seemed on the tongue in the instant, without the vaguest allusion to anything past or absent. Such are the short-cuts of memory! An orderly, logical sequence which one thinks one *ought* to find turns up missing. And it is not to be wondered at: experience has crowded meaning into shorthand strokes of consciousness. The result is hard to decipher. Here, processes are ground together into a matrix: there, processes are dropped out entirely; the product glows with functional aptness, but the original elements are nowhere to be discovered.

It seems as untrue to assert that when I meet my friend, I necessarily compare him with a memory image of him, and pronounce the two the same before I extend my hand, as to affirm that the chicken ratiocinates before he proceeds to devour his worm.

Just what occurs in the apparently simple cases which we have cited, we cannot always say. The work *seems* to have all been done for consciousness, and it has only to believe and to report, to be credulous and to gossip. A certain stimulus, if preceded by a certain other, *sets* the organism in a particular way. It is a refined case of the dog's 'recognition' of his master. We simply react appropriately to the stimulus. Undoubtedly, affections and moods often contribute to meaning, but in such schematic cases as we have referred to, these, even, are often lacking, and we can scarcely find anything left to explain and vindicate a judgment.

Series III. The observation that a cloud passing across the sun in the interval seemed to affect the 'memory error' suggested the possibility that the character of visual stimulation during the memory interval might influence the fidelity of the memory.[1] If this be true, we concluded that it ought to be most marked in our work with those subjects who are preeminently visual. That is, a *visual* memory should be altered by continuous *visual* stimulation, whereas a motor or other memory should not be so altered. To test this, observers were blindfolded during the interval. It was, however, observed at once that this would not do, since the conditions

[1] We have since found the same suggestion made by Dr. Hamlin (*op. cit.*, p. 58).

under which the two successive stimuli were given were not identical. The first stimulus followed daylight, while the second followed darkness. Successive contrast was sure to interfere. To eliminate this difficulty, the observers received stimulation from the window of a dark chamber placed within a larger dark room. As the eyes were entirely cut off from external stimulation before either gray was presented, the conditions courted were obtained.

The arrangement was as follows: the adjustable color-mixer described above was placed behind a black screen having a circular opening cut in its center just large enough to let through the face of the disc. In front of the screen and at angles of 45° with the plane of the disc sat two reflector boxes holding kerosene lamps. The position of the lamps and the boxes was always the same, and the height of the lamp flame was kept constant by measurement. The dark box enclosing the observer faced the screen. The observer placed his head in a wooden mask (2 meters from eyes to screen), adjustable vertically, and at a signal pulled open two sliding doors set on the cylindrical front of the mask. The doors when open exposed the disc to both eyes. They closed in front of the nose by means of an elastic band and moved outward and backward in opening. They were supplied with cords and pulleys to be operated by the experimenter, but it was found to be more convenient for the observer to operate them. The mask served also as a head-rest, this insuring steady gaze and a constant position.

A warning signal was given 2 seconds before the doors were opened. Each exposure lasted 2 seconds.[1] The light intensity used gave at times very faint after-images for about 5 secs., and occasionally for 10 secs., but these were so weak as to be unnoticed except in a very few recorded cases. Eleven intervals between 2 and 60 secs. were used (Table VII). The short times were taken, to indicate more precisely the influence of time on the qualitative fidelity of the image. Instead of producing the image at the close of the interval, the subjects were asked to make every effort to hold it throughout the interval. When an image disappeared, the subject reported "gone," and when it reappeared, "now." These reports and their times of occurrence were recorded for 1,100 experiments—25 for each interval with each of the four observers (*cf.* Series II).

The stimuli used were grays of 60° and 70° white. This difference, like the one in Series I, was about liminal. Other

[1] Other times were tried but were less satisfactory for short intervals. The dependency of the memory image on the duration of the stimulus ought to be investigated.

intensities were given at times, and the observers were always ignorant of the exact number of stimuli used. All agreed that several were given them.

There were four possible orders for presentation: ab (60°–70°), ba, aa and bb; and three possible judgments: "same," "lighter" and "darker." Five trials were carried through all the intervals for each observer in this order: 2″, 60″, 4″, 50″, 6″, 40″, 10″, 30″, 15″, 25″, 20″; then five of a new pattern with this order reversed, *i. e.*, 20″, 25″, 15″, etc. This succession was chosen to distribute the effects of practice and fatigue. Each sitting occupied fifty minutes in the forenoon, usually at nine or ten o'clock.

The results follow: the figures at the top give the intervals and the letters at the left are those used in the earlier Tables. The zero line shows failures to judge, *i. e.*, obliviscence.

TABLE VII.

	2″	4″	6″	10″	15″	20″	25″	30″	40″	50″	60″	TOTALS.
D	19	20	18	28	31	26	26	23	28	29	28	276
C	60	62	65	62	59	59	58	59	60	53	58	655
L	20	17	14	7	7	11	12	13	8	12	10	131
o	1	1	3	3	3	4	4	5	4	6	4	38
	100	100	100	100	100	100	100	100	100	100	100	1100

If it be true that visual stimulation alters in a definite way the central residues of visual sensations, we should expect that a "dark" interval would pull the memory residue toward the dark, whereas a "light" interval would tend to pull the memory residue toward the light.

If we set our totals for Tables I and VII side by side we have the following:

TABLE VIII.

	L	C	D	SUM.
Table I (light Int.)	251	238	111	600
Table VII (dark Int.)	131	655	276	1100
Table I: % of Errors.	69.5	—	30.5	100
Table VII: " " "	32.0	—	68.0	100

That is to say, in the *light*, 69.5% of all errors made show a *lightening* in the memory; in the *dark*, 68% show a *darkening*

in the memory. This confirms our hypothesis that a "stimulated interval" has an effect upon the visual memory.

Concerning the effect of length of interval upon retention we find, in general, (1) that the C values show a slight decrease in the longer intervals; (2) that the D values show a corresponding increase; and (3) that the L values decrease more rapidly than the C values. We notice, therefore, that the memory loses slightly in accuracy as the interval increases from 2″ to 60″, and that the tendency of the memory to darken becomes more pronounced.[1] For the intervals 2″, 4″ and 6″ the number of D and L cases is practically the same. The accuracy of the memory is greater in this series than in Series I and II. Here, only 38.4% of all judgments are error judgments; in Series I, 60.3%; only a rough comparison can be made with Series II. The difference in accuracy is probably partly due to the length of interval, but doubtless the difference in general conditions and the Δ used have something to say.

Images and Individual Differences. The habitual memory modes of our various observers have already been discussed under Series I and II. We found that *K* was strongly visual, *S* less so, while *C* and *G* used visual imagery with difficulty, *G* relying mainly on verbal associates and *C* on organic sensations and feelings. Constant introspective reports during Series III confirm the accuracy of this evaluation. With the emphasis now on the image (reported through the interval) *K* depended entirely on visual residua; *S* more than before; *G's* visual memory was slightly aided; while *C's* habitual modes seem to alter scarcely at all; in fact, these seemed at times to be accentuated.

The distribution of their judgments stands as follows:

TABLE IX.

SUBJECT.	L	C	D	0	SUM.
K	16	173	85	1	275
C	34	191	32	18	275
G	41	152	67	15	275
S	40	139	92	4	275
	131	655	276	38	1100

Each observer showed various fluctuations in the number of

[1] We find nothing to corroborate the periodicity of memory noted by Dr. Wolfe and others. The reappearance and disappearance of the image through the interval seems to be partly a matter of visualizing capacity and partly a matter of attention.

D judgments at different intervals, but these seem to be without special significance (v. p. 43, note).

G had a memory after-image 259 times out of the 275; this began immediately after the first stimulus went, and gradually faded away.[1] In the 8 intervals, 10″—60″, the time of the image was nearly constant. The average duration was 5.8″ with an *m. v.* for the various intervals of only .5.[2] According to the subject's iterations, the images constantly grew darker. Since a true visual memory image rarely came to *G* after the disappearance of the memory after-image, we conclude that the darkening apparent in the results is due to the scanty visual factor, the memory after-image, which the observer was able to command by her best effort.

C's retention in this series was evidently in terms other than visual. The verbal element, as before, played a part and was assisted by the strong feeling tone and organic sensations. The observer herself considered the intensity of certain strain sensations to have adopted the function of memorial retention. The retention times that she reported are evidently due to this, and are not indicative of real visual memory after-images. They stand as follows for the various intervals: 2″, 4″, 6″, 9.2″, 13,″ 14″, 20.4″, 23.2″, 27.5″, 30″, and 31.8″. Occasionally a second "reproduction" was reported in the interval, but this lasted a very few seconds and vanished. Cases of immediate judgment without conscious comparison were exceedingly frequent with this observer. These, we conclude, are to be explained by the psychophysical "set" of the organism, which did duty for a more conventional memory contents. The juxtaposition of this memory representation and the second stimulus was the immediate incentive to the reproduction of the word "same" or "lighter" or "darker" without the emergence in consciousness of a comparison. One cannot emphasize too strongly the tendency of the organism to cut corners, and to avoid logical categories whenever they are superfluous.

K calls for little comment. His visual image was nearly always at hand when the second stimulus was presented. *S* gained somewhat in her visual mechanism; while she was not so typical as *K* she was decidedly visual in her memory. The interference by visual (stereotyped) associates will probably account for the smaller number of her D judgments.

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[1] The difference between sense and memory after-images was insisted upon, and fully understood by the observer. Fechner's distinctions were kept in mind.

[2] Fullerton and Cattell (*Perc. of Small Diff'ces*, p. 149) observe that the memory image with lights seems to last 9 secs. Probably this is the memory after-image proper. A. H. Daniels thinks that the memory after-image lasts less than 15 secs. if the attention is withdrawn.

Subsidiary Methods. I. Recall and Selection. A number—3 or 5—of slightly different colors (papers) were exposed successively by a Jastrow drop apparatus. At the close of the interval (5 or 10 minutes), the observer was asked if he remembered one of the colors (say the second in the series). If he did, a longer series (10 or 12) was presented as before, and he reported when the remembered color appeared. When approximately the same brightness was used throughout the series, no constant direction of change was observable: when, however, a series of brightnesses, *i. e.*, 14 reds, greens or violets running from light to dark, was given to select from, 58 correct selections, 17 too-light, and 6 too-dark were made.

Here again, then, with the light-adapted eye (daylight), the memory grows lighter.

II. Burette Method. The subject looked toward the light through an aqueous solution of a pigment contained in a thin glass jar (width 15 mm., height and length 65 mm.). After an interval, the condition of the image was ascertained and then a weaker or a stronger solution was shown and altered by burette droppings until the subject pronounced the color to be the same as that represented by the image. The color was faded by simply adding water from the burette, and deepened by adding a saturated solution of the pigment. The value of the solution was always known in terms of volume of water and weight of the color-stuff. A screen hid from the observer everything but the solution, which was continually stirred by a glass rod.

III. Direct Production. A color was spread as evenly as possible on heavy white paper, and after an interval (1 or 5 mins.) the observer was allowed (using the same materials) to reproduce the color. The errors due to the method were found to be much larger than the proper 'memory error.' In about half the cases the produced color was lighter and in the other half darker than the memory stimulus. (The two were equated by making them into discs and adding a white sector to one or the other.) The method may be of use where very long memory intervals are involved.

None of these secondary methods proved to be entirely satisfactory, though each promised some tempting advantage. It seemed particularly important at the outset to try direct 'production' and 'reproduction' methods since these appeared to offer the best conditions for the isolation of the image. But after our previous criticism of methods, the partial failure of these auxiliary ones may be explained. We have found, in connection with these, (1) that it is impossible to get a well-graded series in paper colors (outside the discs), (2) that successive contrast must be avoided, (3) that solutions tend to be not

uniform, and introduce too large errors for qualitative memory work, (4) that it is difficult to spread an even surface of color, and (5) that the time and conditions required for 'production' introduce special errors.

We suggest as more ideal stimuli than we have ourselves employed: (1) for colors, a spectrum with a movable narrow slit, and (2) for brightnesses, a constant lamp in a sliding plane with a photometric screen for the projection of rays.[1] These suggestions are made because we have found the examination of qualitative fidelity of simple contents to require more refined and discriminating methods than we at first thought necessary. That is to say, for short times, the amount of change in a constant direction of the memory image is quite small, and can be isolated only by great care and under the most favorable conditions.

CONCLUSION.

After an examination of the memory literature, we have to say that investigations have been, for the most part, directed to memory as the capacity for retention, and to the various factors which condition retention. Reproduction and recognition have been used uncritically and their real basis has often been misconceived. 'Reproduction' not infrequently results from the combination of peripherally excited sensations —special and organic—with a recollected memory core, or simply a word, which may be quite different from the original experience in point of contents. As Professor Kuelpe expresses it (*op. cit.*, p. 190): "Der eigentlich psychologische Vorgang kann daher bei der Erinnerung und bei der Phantasie sehr mannigfaltiger Natur sein, d. h., die Bewusstseinsinhalte, welche als Erinnerungsmotiv gelten oder als Phantasien aufgefasst werden, können ebensowohl ganz verschieden sein, wie die besonderen Urtheile, die ihnen eine solche Bedeutung beilegen." Simple recognition stands much nearer positive or negative identification (expressed by affirmative or negative judgments) than it does to pure memory, and the alleged act of comparison with a memory image is rather a logical formulation, suggested by the judgments 'like' and 'different,' than a psychological statement of fact.

A static as well as a genetic view of mind brings us to the conclusion that the image is a late development, and that its primary function was to prepare the organism for future adjustments. From this standpoint are explicable the partial passage of memory into phantasy, and the weakening of memory fidelity.

[1] *Cf.* Fullerton and Cattell, *op. cit.*, p. 135, and Hess and Pretori, *Archiv für Ophthalmologie*, XL, 4, pp. 1 ff.

The experiments carried on for the special investigation of the visual memory image and its fidelity to an original presentation lead us to the following conclusions.

I. Even as simple a stimulus as a colored or gray disc permits a noteworthy latitude in modes of memory which individual psychology would do well to consider. (1) An observer who is pre-eminently visual may image the color or brightness directly. (2) Names, or verbal descriptions or associates, are not, however, entirely excluded, and become of primary importance where the verbal type of memory is strong and the visual deficient. (3) There is marked evidence of the influence of feeling on memory, wherever the affective reaction of the individual varies within a series. And finally, (4) strain sensations about the head and in the trunk, with, perhaps, general bodily sensations, seem to facilitate retention and recognition in certain cases.

II. Discs—grays and colors—shown and remembered in daylight tend to grow light in the visual memory. This fact was supported by all of our observers but one, who is very deficient in visual images, and confessed that names and verbal associations mediated her memory for the discs.

III. Discs—grays—shown in a dark chamber display a tendency in the visual image to grow dark during an unilluminated interval. No lightening is observed with unilluminated interval.

IV. These last two points (II and III) persuade us that the condition of the retina in respect to stimulation during the memory interval is important for the memory image. Illuminated and unilluminated intervals, where all other conditions are constant, are followed by different judgments with the same memory stimuli. We conclude, therefore, that in all experiments with brightness and color, where a time interval is involved, care should be taken to control the state of the visual organ. It is not improbable that a similar caution would apply to other sense memories. This obvious influence of the periphery upon memory indicates the close connection (perhaps the identification) of the sense and memory centers, in the cortex.[1] It also shows that the memory is not to be regarded as a storehouse of perfectly conserved images, but that the most simple memories are continually exposed to change, and that it is, at times, only

[1] Against this noteworthy influence of sensation upon image we have the indication (*v.* note above, p. 21) of a qualitative difference between the two. These two things do not, at first sight, seem to find explanation in the current theories of central localization. It seems wise, at this juncture, to suspend judgment on the various theories—even Flechsig's separate-centers theory—and to wait for more decisive evidence.

by the combination of various memorial resources that retention is made definite and exact. The value of language in this connection is apparent.

V. The length of memory interval has some influence upon the accuracy of visual memory and the lack of fidelity. From two to six seconds no constant direction of change is shown; memory loses slightly in accuracy from ten to sixty seconds, and the direction of change is constant. The degree of infidelity increases above one minute: it is greater at five minutes, and probably reaches its maximum at a much longer period. The memory image, on the other hand, we find to be more readily producible after five minutes than after one minute.

VI. Images can be called up in a large majority of cases of brightness and color stimulation (499 out of 600—or five-sixths—in one of our series). Where the image is available memory is slightly more accurate. It frequently occurs, however, that recognition is perfectly sure and precise where no recollection through an image is possible.

VII. Where the memory after-image is isolated from the true memory image its average duration is found to be quite constant.

THE PSYCHOLOGY OF HOBBES AND ITS SOURCES.[1]

By V. F. Moore, Ph. B., M. S.

Among the pioneers of English thought in the modern era, the figure of Thomas Hobbes is one of peculiar interest. A clear and vigorous thinker, a man of sturdy and uncompromising mould, he stimulated other minds to challenge as well as to develop the principles he laid down. His influence as conditioning the subsequent development of ethical and political theory is everywhere granted; that he was the founder of English Psychology is, perhaps, not so generally recognized. Certainly we shall not expect to find in Hobbes a complete and perfectly systematized psychology, free from the crudities of pioneer thinking; we shall not forget that the vast field of the physical sciences was, at this period, a newly discovered and as yet, for the most part, unexplored territory. It is the writer's aim, in what follows, to piece together Hobbes' system of psychology from his various works, and to show the connection of his doctrines with prior thought. Our sources are the *Leviathan*, the *De Corpore*, the *De Homine*, and *Human Nature*. All references are to Molesworth's edition of Hobbes' English Works.

Hobbes makes psychology a department of anthropology, or the science of man. Man's nature is the "sum of his natural faculties and powers," and these faculties and powers are further classified as animal and rational, according as they pertain to the body or the mind. (*H. N.* I, 4-5.) Thus, at the start, the subject-matter of psychology is clearly marked off by Hobbes. Psychology deals with man's rational powers in distinction from his bodily powers. The powers of mind are of two sorts, cognitive and motive. The former, which Hobbes terms, also, imaginative or conceptive, is that power by which men get those images or representations of the qualities of external things from which all our knowledge is derived. (*H. N.* I, 7.)

Two points here are worthy of note: and, first, that the attitude of Hobbes is quite strictly non-metaphysical. He is nowhere concerned with the nature of mind as a substance. Sometimes, indeed, he would seem to imply the existence of a substantial

[1] From the Psychological Seminary of Cornell University.

mind, but oftener he merely assumes mind of some sort, and passes on to the consideration of the mental powers. The second point to be noted is that his method is empirical. He intends, he says, "not to take any principle upon trust, but only to put men in mind of what they know already, or may know by their own experience." (*H. N.* I, 2.) He distinguishes two kinds of knowledge,—knowledge of experience, and knowledge of truth, or science. Both have their origin in sense, however; it is a question only of remoteness from that origin. To quote Hobbes himself: "Both are but experience; the former being but the experience of the effects of things that work upon us from without; and the latter experience men have from the proper use of names in language; and all experience being but remembrance, all knowledge is remembrance." (*H. N.* VI, 1.) Hobbes' method then is to consist in a rational interpretation of sense-data, and this method can itself have no other origin than sense. (Cf. *De Corp.* I, 1, 2; I, 6, 1.)

The study of the cognitive powers begins then with an inquiry into the nature of sense. In the *De Corpore* Hobbes approaches the problem by way of physics, a fact which is significant for his psychological theory, and indicative from the start of the mechanical view which shapes his thought. Of all phenomena, he says, the most wonderful is "that some natural bodies have in themselves the patterns almost of all things, and others of none at all." (*De Corp.* IV, 25, 1.) To the explanation of sense as a property of physical bodies to be accounted for by physical laws, he directs his efforts.

It is the "great deception of sense" that color, shape, sound, and other experiences of the sentient subject seem to be qualities in the object; indeed "the contrary must needs appear a great paradox." What is the truth in the matter is stated by Hobbes with the greatest clearness in four propositions, which reduce to the following. The subject wherein the image is inherent is not the object or thing seen; there is nothing without us that can be called color, or sound, hardness, odor, taste, or the like; the things that really *are* in the world without us are those motions by which the appearances of sense are caused. (*H. N.* II, 4, 10; *De Corp.* IV, 25.) Among the proofs by which the foregoing propositions are established is mentioned the phenomenon of light produced by a blow upon the eye, in which case the sensation obviously corresponds to nothing external save the motion which caused it. That ideas or phantasms are caused by motion is evident, Hobbes reasons, from the fact that they change, now appearing, now vanishing; and all mutation is due to motion.

The cognitive process may be analyzed into three factors or stages. First, an impression made upon an organ of sense by

pressure of some external object, the pressure being exerted either immediately, as in taste and touch, or mediately, as in seeing, hearing, and smelling. Secondly, this motion is continued, by means of the nerves, within the living body to the brain and thence to the heart. Thirdly, this inward motion causes a reaction at the center of life, and "an endeavour outward," which gives rise to the phenomena of sense. This outward endeavor occurs only when the reaction acquires a certain degree of strength; it explains, moreover, the external reference of sensation. A complete definition of sense is, therefore, that it is "a phantasm made by the reaction and endeavor outwards in the organ of sense, caused by an endeavor inwards from the object, remaining for some time, more or less." (*De Corp.* IV, 25, 2. Cf. also *Leviathan* I, 1.) The entire process is mechanical.

Hobbes enumerates five senses: sight, hearing, smell, taste, and touch. These have each its own sense-organ proper, and nerve for the transmission of the impression to the brain, but the internal mechanism—that is, the nerves leading to the heart, the heart itself, and the arteries which connect it with the brain—is common to all. The proper organs of touch are the nerves and membranes dispersed through the whole body. In his brief description of the sense-organs, it is evident that Hobbes was conversant with the physiology of his day, though he found it meager enough for the purposes of his psychology. Under sensations of sight are included light and color, color being "perturbed" light; under touch he mentions hardness and softness, heat and cold, wetness, oiliness, and "many more which are easier to be distinguished by sense than by words." Motion, rest, magnitude, and figure are common to sight and touch; smoothness, roughness, density, and rarity refer to figure, and are therefore likewise common to sight and touch. Sight and hearing are treated with special fullness and intelligence. (*De Corp.* and *De Homine.*) Since the nature of sense consists in motion, but one impression is possible at one and the same time, for the organ cannot be busied with two or more motions at once. Thus if two objects work together, the result will be one sensation compounded of the action of both.

Under the term imagination, Hobbes includes the phenomena of memory-images, of dreams, and of fancy, with a brief notice of after-images. The cause of memory he finds in the fact that the motions excited by the impressions of objects do not immediately cease on the removal of the object, but persist within the organism. This he proves by explicit reference to the law of inertia. (*Lev.* I, 2.) The motions produced by an object that has been removed are gradually obscured or over-

come by new motions, resulting from new impressions upon the organs. The memory-image, then, is "sense decaying" or weakening in the absence of the object. To this decay of sense is due the gradually increasing dimness and vagueness of memory-images, and the dropping out of particulars. Distance in time has an effect similar to that of distance in place, in that the whole grows dim, and loses distinction of parts, while the finer details are lost from sight. (*De Corp.* IV, 25, 7; *Lev.* I, 2; *H. N.* III, 1, 7.)

The phenomena of dreams possess a great charm for Hobbes, and he recurs frequently to the subject in the course of his writings, bringing new bits by way of comment and explanation. The images seen in dreams, he says, "have also been previously before the sense, either totally or by parcels." They differ from memory-images proper, however, in that they are, as it were, centrally excited; they result from motions originated in the heart; as, for example, cold in the internal organs generates fear, and "causeth to dream of ghosts." He notes also the incoherence of dreams, as compared with the experiences of sense, and their frequent absurdity as well.

The phenomena of after-images and of the *Eigenlicht* of the retina did not escape this acute observer, though he classes the latter with the former. "There is yet another kind of imagination which for clearness contendeth with sense, ... and that is when the action of sense hath been long or vehement; and the experience thereof is more frequent in the sense of seeing than the rest. An example whereof is the image remaining before the eye after looking at the sun. Also those little images that appear before the eyes in the dark . . . . are examples of the same." (*H. N.* III, 5.)

Memory has for Hobbes, also, the function of a sort of "sixth sense," or an "internal sense." For by the senses we take notice of the objects without us, "but we take notice, also, in some way or other, of our conceptions; for when the conception of the same thing cometh again, we take notice that it is *again* . . . . This, therefore, may be accounted a sixth sense, but internal, and is commonly called remembrance." (*H. N.* III, 6.) And in the *De Corpore*, memory has assigned to it the comparison of images, and the judgments as to likeness or difference. (IV, 25, 7.)

Fancy is distinguished from memory by two factors. It has no reference to the past; and while it draws all its material from sense, fancy arbitrarily combines and rearranges the elements thus given, as when it constructs a centaur or a mountain of gold. (*Lev.* I, 2; *H. N.* III, 4.)

Hobbes has a fairly definite and intelligible theory of Association, and one which follows logically enough from this

explanation of sensation. The succession of ideas may be either casual or orderly. Even in the former case, that of "ranging" thought, the apparently disconnected ideas may often be reduced to order by the discovery of a hidden bond of union. The orderly sequence of ideas, or "discourse of the mind," is the rule in adult mental life, and is directly conditioned by the fact that the original motions arising from the sense-impressions occur in a given order. "We have no transition," he expressly states, "from one imagination to another, whereof we never had the like before in our senses." For all ideas are motions, relics of those made in sense, and those motions that succeeded one another in sense continue together in the same order after sense, "in so much as the former, coming again to take place, and to be predominant, the later followeth by coherence of the matter moved, in such manner as water upon a plane table is drawn any way one part of it is guided by the finger." (*Lev.* I, 3.) But since in experience any given impression is followed now by this impression, now by that other, so in the mental series, association may take one of several directions, and its course cannot be predicted with certainty. This much only is certain, that each member of the series will follow its predecessors in an order at some previous time established in experience. Association by contiguity is then the sole form of association recognized by Hobbes. He does not use the term contiguity, however, or, indeed, that of association. He gives as an example of the succession of ideas the thought of St. Andrew suggested by that of St. Peter. Examples of purposely guided or regulated trains of thought are the retracing in memory a series of events, in order to fix the time and the occasion of the loss of a certain article; the passing from an event to the consequences known by experience to follow from that event, or from an imagined end to the means to that end, are cases to the point. (*H. N.* IV, 2.)

Finally in his discussion of the cognitive powers, Hobbes treats of reason. (Cf. *Lev.* I, 3, 4, 5; *De Corp.* I, 1, 2; *H. N.* IV, V.) This is a subject of peculiar difficulty for him, for since all knowledge is derived from sense, and all association of images follows the order given in sense, reason would seem to be restricted to a narrow sphere of activity. Hobbes' statement is somewhat obscured, moreover, by his differentiation of prudence from reason. By prudence he means simply forecast of the future, based upon experience. It is an accurate linking of cause and effect by means of association. As such, it is not confined to man, but is shown in some measure by animals. Reason is a higher power than prudence; it is not, like sense and memory, born with us, nor yet gained by

experience only, like prudence, but, on the contrary, is attained by industry. It consists first in an apt imposing of names, and secondly, in an orderly method of proceeding from names to their connection in propositions. The mind can have no thought or knowledge not ultimately derived from sense. Everything that is thought is particular; there are no general ideas. Names only are universal; and names are arbitrary symbols invented by man for his convenience in communicating ideas. The formation of propositions by the addition and subtraction of names, is judgment; the further manipulation of propositions into syllogisms is reasoning. Reasoning thus reduces to a form of reckoning. Reason is the peculiar mark by which man is distinguished from the animals. Children have not the power of reason until they have learned the use of speech. They may be called rational creatures, however, since they are capable of acquiring reason.

Hobbes' discussion of pleasure and pain is entirely consistent with his explanation of the cognitive powers, and forms the transition to the motive power. Pleasure and pain form, as it were, another kind of sense; they arise in consequence of the motion propagated from the sense-organs inwards, as do sensations. Motions communicated from without and continued within the body differ, however, according as they reinforce or hinder the vital motion of the organism. A motion which helps vital action is productive of a sense of pleasure, and issues in a reaction or endeavor termed *appetite*. On the contrary, a motion which hinders or impedes vital action gives rise to pain, which is the subjective counterpart of the endeavor termed *aversion*. Here we have, surely, a noteworthy anticipation of later theory. (Cf. *Lev.* I, 6, and *De Corp.* IV, 25, 12.) The internal reference of pleasure and pain is explained by the direction of the primary motion inwards, as the external reference of sensation was explained by the outward motion.

On the basis of pleasure and pain as phenomena accompanied by appetite and aversion,—endeavor towards a good, or away from an evil,—all the passions are explained. Besides the pleasures and pains of sense, are those of expectation, based upon experiences of sense. Hence, from the primitive desire and aversion are derived joy, grief, hope, fear, benevolence, anger, pity, envy, etc. The genesis of some of these is traced out at length, and in a manner which constantly suggests modern English thinkers. This derivation of the passions and emotions from self-regarding impulses has, however, more significance for ethics and politics than for psychology, and need detain us no longer.

From his discussion of pleasure and pain as subjective

aspects of appetite and aversion, Hobbes proceeds to a purely mechanical and deterministic theory of volition. A man is oftentimes in doubt concerning a thing, whether it promises good or threatens evil, and in this case appetite and aversion alternate. Or two objects of desire may be contemplated, one of which must give way to the other. In such cases, the mental state is that of *deliberation*, and the last appetite or aversion, "immediately adhering to the action or to the omission thereof, is that we call the *will*." (*Lev.* I, 6.) In common speech, indeed, we may say a man had a will to do thus and so, but forebore to do it; strictly speaking he had an inclination only. For will is the last appetite in deliberating, and is not divorced from action save by external constraint. Appetite is the internal endeavor or reaction upon some object of desire; will is the issuing of this endeavor in outward action. It makes no essential difference for Hobbes' doctrine that the object of desire may be either real or ideational.

It follows, of course, that the will is determined, and not free; for "where there is appetite the entire cause of appetite hath preceded; and consequently, the act of appetite could not choose but follow, that is, hath of necessity followed. And, therefore, such a liberty as is free from necessity is not to be found in the will either of men or beasts." (*De Corp.* IV, 25, 13.) Or, as it is stated in yet more forcible terms in the essay *Questions Concerning Liberty, Necessity, and Chance:* the choice I shall have of anything hereafter, is now as necessary as that fire will burn any combustible matter thrown into it. (*Eng. Works*, V, 295.)

The distinction between "animal" and "vital" motion corresponds to that between voluntary and non-voluntary action. Examples given of the latter are the circulation of the blood, respiration, nutrition, and other vital processes; of the former, speaking, walking, and the like. Hobbes calls attention to the fact that imagination is a factor in all voluntary motion, since all such motions "depend upon a precedent thought of whither, which way, and what." (*Lev.* I, 6. Cf. *H. N.* XII, 3.)

We have now before us, in brief, the psychology of Hobbes. From our more advanced point of view, it would be easy to point out its flaws and short-comings. Yet the range of mental phenomena included, the acuteness of observation shown in the description and explanation of the phenomena, and the general consistency of Hobbes' views with one or two fundamental principles, combine to produce a fairly clear-cut and comprehensive system. At least we may say that in spirit and aim, psychology begins to present the aspect of modern em-

pirical science. Furthermore, some of the modern problems have been raised, some of the modern solutions anticipated.

In seeking the sources of the psychology of Hobbes, we turn very naturally first to Francis Bacon. We are accustomed to look to Bacon for the beginnings of science; but is it true that psychology owes to him a debt distinct from that shared with her sister sciences? In order to answer this question, let us seek to learn in how far Bacon's writings may be said to contain a psychology, and of what sort it is. Then only shall we be prepared to say to what extent, if any, Hobbes was influenced by it in framing his own system.

In the *De Augmentis* (Bk II, ch. 1) Bacon divides all knowledge into History, Poesy and Philosophy, this division being based upon the psychological analysis of the rational soul into the three faculties, memory, imagination, and reason. History, which includes natural as well as civil history, consists in the last analysis of the facts of experience, first presented to the senses, then stored up in the memory. Poetry pertains to the imagination, by which the images of sense are variously sorted, disjoined, and formed into new and arbitrary combinations. Reason, dealing still with the given of experience, analyzes and classifies its material, and the result is philosophy, —knowledge concerning God, nature and man. History and poetry are thus concerned with individuals, but philosophy discards individuals, "neither does it deal with the impressions immediately received from them, but with abstract notions derived from these impressions; in the composition and division whereof according to the law of nature and of fact, its business lies." Here we have, in the germ, a "faculty"-psychology of a strongly empirical tendency. Knowledge begins with the particulars of sense-experience, and rises by means of the elaboration of these to general principles. (Cf. *Nov. Org.* I, 1; 19–22.)

In his further classification of knowledge, Bacon divides the doctrine of man into the Philosophy of Humanity and Civil Philosophy; under the first of these psychology finds its place, together with physiology. (*De Aug.* IV, 1.) It is somewhat startling to the reader keen for modern problems to find that the inquiry as to the nature of the bond between body and mind assumed for Bacon a place of chief importance. It is not, however, the modern problem which engages him here, but rather that of the sympathetic relation of the mental and the physical sides of man's being.

Bacon accepts from Greek philosophy the division of the soul into rational and irrational. The rational soul is divine, the breath of life breathed into man by God. As such it is incomprehensible and inexplicable, and all questions concerning its

nature belong not to psychology, but to theology. The irrational soul, however,—or, as Bacon also designates it, the "sensible" or "produced" soul—belongs both to man and to the brutes, and this forms a fit subject of human inquiry. "It must clearly be regarded as a corporeal substance, attenuated and made invisible by heat; a breath compounded of the natures of flame and air, having the softness of air to receive impressions, and the vigor of fire to propagate its action; nourished partly by oily, partly by watery substances; clothed with the body, and in perfect animals residing chiefly in the head, running along the nerves, and refreshed and repaired by the spirituous blood of the arteries." (*De Aug.* IV, 3.)

Bacon is as explicit concerning the functions of the irrational soul as concerning its nature. It is the organ of voluntary motion and of sense. He complains that neither of these powers has been properly investigated; the bare fact that the body is set in motion by the spirit, a substance vastly more subtle than the corporeal mass, is, he urges, a fact surely deserving careful inquiry, but one that has hitherto escaped it. Bacon's purpose here as elsewhere is rather to outline the problems involved, and to point out the directions which investigation should take, than to give even a tentative solution.

In his treatment of sense and the sensible, Bacon is chiefly concerned with the distinction between sensation and perception. By perception, however, he means something quite different from what that term signifies for modern thought. "Perception," for Bacon, is common to all bodies, inanimate as well as animate. All bodies, he says, exercise a kind of choice in receiving what is agreeable, and excluding what is hostile or foreign, as for instance when the magnet attracts iron, or two bubbles unite on approaching. Within animate bodies also, certain processes occur which are analogous to the examples just cited, as for instance the beating of the heart, the processes of digestion, etc. (*De Aug.* IV, 3.) All such processes or affections of bodies are, it is urged, to be carefully distinguished from sense. The distinction would seem to be that between unconscious or reflex processes and conscious affections. (See Fowler's Introd. to the *Nov. Org.*, 18–19; also Kuno Fischer's *Francis Bacon*, 273–274.) Everywhere in nature, Bacon would show, is found a receptivity for impressions appropriate to the particular body in question. The bit of iron, the chip of wood, the drop of water, each receives or repels according to its nature. Within organic bodies this primal capacity reveals itself in processes of greater complexity. In sensation, the receiving of impressions is accompanied by *consciousness* of that which is received, a new element, and one demanding attention and explanation. "Men have not seen clearly enough

of what nature the action of sense is; and what kind of body, what length of time, or what repetition of impression is required to produce pleasure or pain. In a word, they do not seem at all to understand the difference between simple perception and sense; nor how far perception may take place without sense. Neither is this a dispute about words merely, but about a matter of great importance." (*De Aug.* IV, 3.) Thus Bacon summons science to an investigation of the phenomena of sensation.

This discussion of sensation in the *De Augmentis* should be supplemented by certain passages from the *Novum Organum*, wherein Bacon points out that the impressions of sense are faulty, since they both fail us and deceive us, and hence the need of instruments to aid the senses, and of experiment. Furthermore, there is an especial liability to error in passing from sense-impressions to judgments. (*Nov. Org.* I, 50, 69.) The *Idola Tribus* and the *Idola Specus*, tendencies to error grounded respectively in human nature itself and in the peculiar constitution of individuals, have a bearing upon problems of psychology, in that they mark a distinction between sensations within us and things without us, and raise the question as to the nature and correctness of our perceptions, as well as note the fact of individual variations in psychical functioning. (*Nov. Org.* I, 41–42. See also K. Fischer's *Francis Bacon*, 82–83.)

According to Bacon's classification, the understanding and reason are delegated to logic; the will, affections and appetites to ethics. Logic and ethics, therefore, fall under psychology. Imagination acts as a messenger or proctor in both provinces, carrying over the images of sense for the judgments of reason and the mandates of the will. (*De Aug.* V, 1.) Incidentally he comments upon the part played by imagination in voluntary motion. The image serves as the object and guide of the motion, as proved by the fact that when it is withdrawn the motion is immediately interrupted. As an example he cites the case of a person walking, and brought to a standstill in consequence of absorption in some object of thought.

The faculty of memory is treated briefly in the *De Augmentis* (V, 5), and at greater length in the *Novum Organum* (II, 26). Bacon's discussion of memory is prompted by the practical aim of establishing an effective mnemonics, but has interest as containing some forecast of a theory of association. He enumerates six ways by which memory is facilitated. (1) By cutting off of infinity of search, which may be done by noting the order or distribution, by the artificial assignment of "places" (either places in the proper sense of the word, or any arbitrary sign, as words, letters, historical persons, and the like), or by taking advantage of the rhythm and rhyme of

verse. (2) By the reduction of the intellectual conception to a sensible image. (3) By impression made on the mind in a state of strong emotion. (4) By impression made on the mind when unoccupied with anything else either before or after. (5) By a multitude of circumstances or points to take hold of. (6) By expectation.

The will, as has been said, falls within the sphere of ethics, and is considered by Bacon wholly with a view to practical or moral interests.

Not the least interesting and instructive of Bacon's opinions which have significance for our inquiry, are those found in the *De Augmentis* (VII, 3), where he makes suggestions towards a social psychology. Here he insists that the characters and dispositions of mind be investigated with scientific accuracy, both those which are common to all men, and those which are peculiar and individual. Hitherto astrology alone has concerned itself with this study, and that in a superficial and unscientific manner. He would have a careful investigation now instituted, with a view to ascertaining what are the common and simple elements in mental life, and how these are modified by age, sex, region of country, disease, deformity, station in life, wealth, poverty, prosperity, adversity, and so on. The affections and passions should be included in this research. Philosophers ought carefully and actively, so Bacon says, to have inquired concerning the strength and energy of custom, exercise, habit, education, imitation, emulation, friendship, praise, reproof, and so forth.

So much for Bacon's psychology. To quote Fowler: "It is impossible not to see in these speculations, crude as some of them are, the beginnings of much of the later English psychology." (Fowler's Introduction to the *Nov. Org.*, p. 19.) Bacon gives almost nothing by way of theory; his thought is scarcely systematized. It is not so much a psychology that we find, as suggestions as to what psychology must be. We do not forget that Bacon's service to science in general was not in the form of definite contributions to the sciences, but rather in his insistence on a wider range of investigation, a freer spirit of inquiry, and, above all, a new method. He was the prophet of a new dispensation; gifted with clearer vision than his fellows, he called upon men everywhere to repent of the sins of their enslaved past, and do works meet for such repentance.

In tracing the influence of Bacon upon Hobbes, we find ourselves upon debated ground. The dispute has reference chiefly to the general philosophical influence of Bacon, rather than to the narrower question in which our interest centers, but is not without a bearing upon the matter in hand. Fowler and Kuno

Fischer agree in asserting that Hobbes is the disciple of Bacon, that the thought of the former is rooted in that of the latter, and grows out of it logically and unmistakably. It seems no less certain that other influences, chiefly continental, were at work upon Hobbes, and did much to mould his thought.

But little significance can be attached to the circumstance that in all his writings Hobbes makes but two references to Bacon, and these of a trivial nature. (Nichol's *Bacon* in B. Ph. Classics, Vol. 2, p. 235; Fowler's *Introd. to Nov. Org.*, p. 99.) It is certain that the two men had personal dealings; it seems certain, on the authority of Aubrey, that Bacon employed Hobbes to translate some of his works into Latin, "finding none able so readily to understand his thoughts in them." However this may be, on *a priori* judgment, one would pronounce it to be impossible that Hobbes should have been unacquainted with and uninfluenced by the writings of his distinguished contemporary and fellow-countryman. Bacon's influence upon Hobbes is chiefly a matter of tendency and attitude rather than of direct transmission of doctrine, and for this reason more readily eludes exact definition, while it is not less real and potent.

Perhaps the first thing to be noted in Bacon which has a distinct bearing upon the psychology of Hobbes, is the marking off of the field of psychology from metaphysics. Bacon, we remember, divides the soul into rational and sensible parts. The former, being wholly incomprehensible to human reason, he turns over with cheerful alacrity to theology; the latter furnishes the field of psychology. Thus, at the outset, psychology is guarded in large measure against entanglement with metaphysical questions,—much as we may deprecate the means by which this result is effected. To use Fowler's words: Bacon assumes from the start the ordinary distinction between mind and matter, a universe of objects to be known, and a thinking subject capable, by care and discipline, of attaining to a knowledge of them. (Fowler's *Introd.* to *Nov. Org.*, p. 16.) Psychology is not concerned with the proof of these presuppositions. It is on the same level with the other sciences in that it has for its aim the investigation of a definite group of phenomena. It was no small service in the interests of psychology thus early to define its sphere and to insure its title to a place among the sciences.

In this dualism of Bacon's, just noted, is to be found, doubtless, one source of the materialism of Hobbes. As Kuno Fischer says, the hiatus between the rational and the sensible soul led logically to the denial of that which is in itself inexplicable, and superfluous for mental life. (*Francis Bacon*, pp. 270-271.) Lange cites as evidence of the materialism of Bacon his high

estimate of Democritus, whose system he places above all others, and also Bacon's doctrine of "animal spirits." Says Lange: "We have the thing (materialism) in all essential respects in Bacon, and we are only restrained from designating Bacon as strictly the restorer of the materialistic philosophy by the circumstance that he fixed his attention almost exclusively upon method." (Lange's *Hist. of Materialism*, I, 236.) Bacon's psychology is virtually materialistic, that of Hobbes frankly and explicitly so.

Along with Bacon's service in defining the field of psychology must be named that other incalculable service of indicating its method. Psychology, as well as the other sciences, must proceed by induction. In the case of psychology no less than of the physical sciences does Bacon bewail the lack of patient and accurate observation and collection of facts. He does not seem to have foreseen the possibility of the application of experiment within the field of psychology, but his spirit is essentially that of modern scientific research. We have already noted that Hobbes proceeds by the empirical method. He does not profess Bacon's disdain for deduction; instead, he combines deduction with induction. He is far too thoroughly imbued with the spirit of Bacon to pass over the importance of facts, or to think he has explained when he has merely described.

In close connection with the above we must note the sensationalism of the psychology of Hobbes. Bacon had insisted upon experience as the sole source of knowledge. But according to his psychology experience is reducible to sensuous elements. The higher processes of thought and inference are, first for Bacon as later for Hobbes, merely means of elaborating the material furnished in sense. Nothing new is added at any stage in knowledge. Words are but arbitrary signs attached to groups of things for convenience of reference. Hence follows "a predilection for a mechanical theory of the universe." (K. F.'s *Francis Bacon*, 412.) Sense holds the same fundamental place in Bacon's psychology as in that of Hobbes. Upon it all higher functions are built, to it they appeal for their entire contents. Bacon shows also, but to a much less marked degree than Hobbes, the tendency to seek in physiology the adequate explanation of psychical phenomena.

To mention some specific and minor points of the indebtedness of Hobbes to his predecessor. Bacon had already emphasized the subjective character of sensation: color, sound, and other sense qualities exist for the sentient subject, not as properties in the object. (*Nov. Org.* I, 41-42.) Bacon's peculiar doctrine of perception as common to all bodies may have some bearing upon Hobbes's mechanical explanation of sensation. If regarded as the extension to the lower forms of organic life

and to inorganic bodies of a property universal in higher organic life, then the doctrine is an anticipation of Leibniz. For Hobbes it may have meant the extension of the mechanical principle ascribed to natural bodies to mental life. We have to look elsewhere, however, for the true source of Hobbes' mechanical conception.

So far as Bacon explains the physiological conditions of sensation, his statements agree with the fuller explanation of Hobbes. Both give to the heart the primacy over the brain as the central organ of sense, for instance. Hobbes certainly owes to Bacon the suggestion that the ideational element enters as a factor into voluntary motion. Bacon's enumeration of the various ways by which memory may be facilitated may well have led Hobbes on to his own theory of association. Bacon is one of the most suggestive of writers on any theme, and in his psychology the reader is impressed by the numerous suggestions thrown out, foregleams of later thought as they seem in retrospect. One cannot state dogmatically that they influenced Hobbes, or subsequent writers. They may very well have done so.

While the continuity of thought from Bacon to Hobbes is too obvious to admit of permanent doubt, it is equally indubitable that the thought of the latter was shaped in no small measure by the action of another current of influence proceeding from the continent, notably from Descartes and that group of scientific thinkers among whom Galileo shone preeminently. The key-note of the entire speculation of Hobbes is mechanism. "He finds his mission," says Falckenberg, "in the construction of a strictly mechanical view of the world. Mechanism applied to the world gives materialism; applied to knowledge, sensationalism of a mathematical type; applied to the will, determinism; to morality and the state, ethical and political naturalism." (Falckenberg's *His. Mod. Phil.*, p. 72.) We have seen how thoroughly the mechanical view dominates his psychology. Sensation, memory and imagination, affection and will, are all explained by motion, imparted in the first instance by impact. Motion is the ultimate principle. Motion, in accordance with invariable law and capable of expression in mathematical formulae, was at this period the ruling idea of the new physical science. Mathematicians and astronomers were busy revealing a new heaven and a new earth obedient to laws of motion. What more reasonable than the hope that an idea, proved so fruitful in natural science, would prove equally fruitful applied to the varied phenomena of the life of man? This was the thought that lodged in the mind of Hobbes, grew until it dominated

all his thinking, and expressed itself in his system of philosophy.

That Hobbes did actually come in touch with the men who represented most fully the new scientific movement, is established by the facts of his history; and that he was keenly alive to the significance of their work receives abundant proof from direct statements and references to be found in his writings. During the years 1610-1637, Hobbes made three journeys to the Continent, remaining at one time for a period of three years. He made the acquaintance of Gassendi, Mersenne, and Galileo. These journeys are memorable as occasions of fresh intellectual stimulus. It was on the first of them that he took up for the first time the study of geometry, to which he applied himself with infinite zest. During the third journey the idea of motion took possession of his mind. Day and night he was haunted by it, he tells us; whether he sails, drives, or rides, there motion is forever meeting his eye, engaging his thought, and offering itself as the clue to the mystery of the varied universe. It seemed to him that there is nothing real in the world save motion. (*Vit. carm. exp.* L, 1, 89. See, also, Robertson's *Hobbes* in Bl. Ph. Classics, pp. 33-34.) Returning in 1637 from his third tour on the Continent, he found England rent by partisans and on the verge of civil war, and, after a brief tarry, went abroad again, remaining this time for eleven years. This period of his exile covers the productive years of the life of Descartes, who was himself an exile in Holland for prudential reasons, but made several visits to France during the time of Hobbes' protracted residence there. Mersenne was in communication with Descartes all the while, and it was through his efforts that Hobbes was induced to add his "objections" to those appended to the *Meditations*, which appeared in 1641. We learn that Descartes was displeased with the tone of Hobbes' criticisms, and would have no further correspondence with their author. (Mahaffy's *Descartes*, Bl. Ph. Cl., p. 95.) Gassendi—of whom Lange says that he was the forerunner of Descartes—was entering upon the period of his greatest literary activity. He became Regius Professor of Mathematics at Paris in 1646, and his lecture-room was crowded with eager hearers. (Lange's *Hist. of Materialism*, I, 263.) Kepler's work had been finished some years before. Galileo was at the height of his fame and activity. His greatest contributions to science had already been made. The law of falling bodies, the diurnal and annual motions of the earth, the ebb and flow of the tide, the discovery and revolution of the satellites of Jupiter,—these and other results of Galileo's research were before the world. Hobbes' own countryman, Harvey, had published his notable

discovery as early as 1628. (*Exercitatio Anatomica de Motu Cordis et Sanguinis.*) It was not until after 1650, subsequent to his return to England, that the chief works of Hobbes appeared in print.

The references made by Hobbes to the scientific thinkers just named are very numerous, being scattered throughout his works, and show him to have been thoroughly familiar with their views. (Notice especially *Epistle Dedicatory*, *De Corpore.*) An interesting bit of personal history, related by Hobbes himself, tells us how his thoughts were first directed to the problem of sensation, and how he turned at once to motion for the key to the solution. In conversation one day with a group of learned men, some one made mention of sense, and another asked in the spirit of Pilate, "What is sense!" No one being able to answer, he was filled with wonder that men of such wisdom should not understand the nature of their own senses, and from that day he pondered the matter. Then it occurred to him that if bodies and their internal parts were at rest, or were moved always in the same way, there could be no distinction of anything, and consequently no such thing as sense. The cause of all things must be sought in diversity of movements. (*Vita*, L, 1, p. xx. See, also, *Hobbes* in Bl. Ph. Cl., 33-34.)

The influence of Descartes upon the psychology of Hobbes deserves a special consideration. The dualism of Descartes set mind and body over against each other in marked antithesis. On one side, everything is to be explained in terms of thought; on the other, in terms of extension and motion. The rationalistic element in Descartes would seem to have had little interest for or effect upon Hobbes. It is Descartes' use of the mechanical principle which is of chief importance for our problem. Descartes it was who, starting out from the idea of motion, first attempted an explanation of the entire universe on mathematical and mechanical principles. We remember that Descartes himself considered his metaphysical theory merely as preparatory to his scientific and mathematical inquiries. (*Essay on Method*, I, 191, Cousin's ed.) Certain epistemological questions must first be answered. His great aim, however, was to work out a complete and consistent mechanical explanation of all natural phenomena. Descartes' "vortex" theory is an attempt to explain the origin and laws of the solar system in terms of motion. (Cf. Mahaffy's *Descartes*, 159-160; *Descartes and His School*, 400-403; see also Tönnies' *Hobbes, Leben und Lehre*, p. 100.) All the phenomena of nature he believes are to be explained as modes of motion. His earliest published statements of his mechanical theory are the essays on *Meteors* and *Dioptric.*

But the phenomena of the life of man, according to Descartes, are likewise capable of explanation by reference to motion. Life itself is mechanism. Human and animal bodies are automata, wholly explicable by the principles of motion and heat. Sensation and appetite in brutes are mere appearances, physical reactions without correlates in consciousness, and even in man they are mechanical processes. (Cf. *Descartes and his School*, 412.) Here, obviously, is the source of the mechanism which pervades the psychology of Hobbes.

Turning from his general conception of nature to his psychology, we find that Descartes recognized six grades of mental function (Falckenberg's *Hist. Mod. Philos.*, 105): 1. The external senses. 2. The appetites. 3. The passions. 4. The imagination, with its divisions into passive memory and active phantasy. 5. The intellect, or reason. 6. The will. Sensations and appetites, since they belong to the body, are mechanical in origin and nature. They are for Descartes, as for Hobbes, modes of motion. Moreover, since he rejects the idea of action at a distance, Descartes makes all phenomena of motion due to pressure. . The passions belong both to body and soul, thus forming a group intermediate between the lower and the higher groups. Mind would not be capable of passion but for the concurrence of the body. The fundamental forms of passion are wonder and desire, the term desire being made to include both the desire to get pleasure, and aversion, or the desire to shun pain. By wonder Descartes seems to mean a state of interest, but neutral as to pleasure and pain. Out of these primary passions all others are elaborated. From pleasure and pain arise desire and aversion; desire and aversion projected into the future are hope and fear; hope and fear realized give rise to joy and grief, and so on. All are strictly self-regarding.

Even this cursory glance at his psychology makes it appear that the profound intellect of Descartes had previously worked over the same ground and arrived at some of the same conclusions as Hobbes. Nor is this to deny to the latter originality of thought. The psychology of Hobbes is no mere resetting of the opinions of Descartes. It has a scent of English soil, and a vigor which testifies to the grappling with problems at first-hand. It is worthy of note, perhaps, that the references of Hobbes to Descartes bear almost without exception upon the speculations of the latter within the field of the physical sciences, but are such as to show familiarity with the details of his thought within that field.

To Bacon, Hobbes would seem to owe his conception of psychology as a science, and the distinctively empirical bent of his

thinking, and to be further indebted to him for various suggestions which he worked out and incorporated in his own system. From Descartes, Hobbes undoubtedly got the conception of nature as a mechanical system, and the idea of the extension of the mechanical principle to physiology and psychology. He went further than Descartes in reducing all mental activity to modes of motion, thus resolving the dualism of Descartes into materialism pure and simple. To the physical sciences of his day, primarily, Hobbes owes the principle by which he explains every form of mental phenomena.

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EXPERIMENTS ON DISCRIMINATION OF CLANGS FOR DIFFERENT INTERVALS OF TIME.

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PART I.

The following research was suggested by the results of experiments on memory carried on by a beginner's class in psychology in Stanford University.

These experiments were of the usual kind on syllables, numbers, weights, tones and lines. They were carried out under fairly favorable conditions as regards isolation, and with much earnestness by most of the class — a condition not always present in beginners' classes in experimental psychology.

The general results of the experiments were not such as to substantiate all the laws of memory as commonly laid down in the text books. It was not found, for example, that the flight of time up to 60 seconds—the longest interval used—made any marked difference in accuracy of discrimination of lines for most of the students. The majority seemed to discriminate as well with a 60-second interval as with 10 or 3 seconds. It was further noticed that the degree of strain of attention during the interval between two stimuli seemed to make but little difference in accuracy of discrimination. One student, *e. g.*, who filled in longer intervals with interesting reading, discriminated between pairs of lines, quite as well for the longer intervals as for the shorter with direct attention.

Again, while some were more accurate with the shorter intervals, others were more accurate with the longer, so that the average of the judgments of about 30 students was almost alike for all time-intervals used. But the experiments on each individual were too few in number, and performed under too rough conditions, to serve other than as hints for more careful and extended work. They led the writers to think, however, that the so-called laws of memory for short intervals of time as commonly laid down in text books may be inaccurate; and, also, that the lumping together of experiments on series of syllables and numbers on one side, with experiments on the discrimination of pairs of successive stimuli on the other, under the common name of "memory experiments," is misleading.

Furthermore, the writers thought it might be worth while to repeat some of the experiments on discrimination of simple stimuli with different time intervals under the conditions of strained and distracted attention,—to repeat, for example, Wolfe's work on Tone Memory, and to supplement it with distraction experiments, in order to gain some insight, if possible, into the nature of the "memory image" of simple stimuli.

The literature of the experimental treatment of memory, so far as it is accessible to the writers, would not seem to indicate that the question of the effects of the flight of time on memory had been definitely settled, or, indeed, that it had been definitely determined what was meant by memory in experimental investigations.

The diversity of result obtained in the beginners' class, referred to above, seems to be a reflection of the diversity of result found in the several special investigations. Wolfe's[1] well known work on Comparison of Clangs, from which he obtains a logarithmic law similar to Ebbinghaus's law for the forgetting of nonsense syllables, will be discussed further on, along with the results of the writers' experiments. In regard to the classical research of Ebbinghaus, as well as of the supplementary work of Müller and Schumann, the writers, as indicated above, do not feel that the effect of the flight of time on a series of muscular actions, practiced till they can be executed mechanically, is to be placed in the same category with the discrimination of pairs of successive, simple stimuli, with different time intervals. As M. Bergson[2] says in the *Revue philosophique*, "The recollection of anything learned by heart, has all the marks of a habit. Like a habit, it is acquired by repetition of the same effort. Like a habit, it requires analysis of an action and then recomposition into the complete effect. Like any habitual exercise of the body, it is incorporated in a closed series of automatic motions which follow one another in the same order and take up the same time."

What is there in running through a complicated series of muscular actions which corresponds to the discrimination of two tones, except the element of the flight of time? The impressions of "like" or "unlike" expressed in judgments, are the data from which the accuracy of the so-called sensory memory is estimated; but the accuracy of reproduction of a series of muscular actions, more or less accompanied by sensory images, and discharging into one another more or less mechani-

[1] Wolfe: Untersuchungen ü. d. Tongedächtniss. *Phil. Stud.*, Vol. III, p. 534.

[2] Bergson: Mémoire et reconnaissance. *Rev. phil.*, Vol. XLI, p. 226.

cally, is the basis for measuring the memory for motor ideas, and a subsequent judgment of the degree of accuracy of reproduction does not form an essential part of the data. Moreover, the consciousness of the serial impressions retreats more and more with practice, into the marginal regions of consciousness, whereas, in the case of discriminative judgments, the attention usually becomes more and more concentrated and the discriminative powers increase with practice.

In this respect, Ebbinghaus's observation on the effects of recognition of syllables on retention seems very pertinent. He found, for example (Das Gedächtniss, S. 80), that syllables, which he had imprinted 8 to 16 times on a given day, appeared new and strange to him on rehearsing them the day following. When, however, the number of preparatory imprintings had run up to 57 or 64, the syllables no longer appeared strange to him on the succeeding day; he greeted them, if not immediately, at least in a short time, as old acquaintances. But he did not find that recognition of the syllables made any difference in regard to their retention. The number of imprintings necessary to memorize the syllables was as great with as without recognition.

Müller and Schumann[1] found a like result in the case of rows of syllables reconstructed wholly from rows already imprinted. When, however, the reconstructed rows were made up in *part* only from previously imprinted rows, they found a saving in time of memorizing accompanying recognition. But this latter condition was attributed by them to a great familiarity with certain syllables, or to some betterment in "disposition," in virtue of which attention and recognition were both increased. The quickening effect on interest of a familiar acquaintance in a mixed translocated series of syllables, as compared with the broad and general recognition of Ebbinghaus's experience, would certainly account for the difference in results. It would seem to the writers as if the classification of the two forms of mental process under the common name of Memory, rests on a loose analogy—viz.: the analogy between the motor tendencies together with more or less of sensory accompaniment, left by imprinting a series of muscular actions, and a so-called memory image resulting from imprinting a sensory image, which is supposed to exist centrally till it is compared with a peripheral sensation. Whether, however, this memory image as such exists in most of our discriminative judgments for small differences of stimuli is doubtful. As will be shown later, explanations of sensory memory based on the existence of a memory image involve one in absurdities.

[1] Exp. Unt. ü. d. Gedächtniss. *Z. f. Psy.*, Vol. VI, p. 319.

Bigham's[1] experiments on memory are of the serial kind, but the imprintings were not repeated till the reproduction became automatic. Using 10 kinds of serial presentations—5 audible and 5 visible—he found, in general, an increase in errors of reproduction with the time. Nevertheless, taking the different kinds of presentations together, using all the syllables and all the numbers (as we understand it), he found that numbers were remembered better after 10 than after 2 seconds, and that syllables were "remembered very much better after 30 seconds than after 2 or 10 seconds." But the reproduction of a series of visible presentations is often attended by, if not due to, muscular action. The names of colors, figures, and numbers are almost unavoidably pronounced as they are exposed, and it is questionable if in this kind of experiment, any more than in those of Ebbinghaus, we have mental processes similar to those involved in discriminating between pairs of stimuli.

Münsterberg[2] compared linear distances with intervals of 1, 3 and 10 seconds, and found an increase in variable error with the time. Lewy,[3] elaborating on Münsterberg's work, found an increase in variable error with the time for intervals up to 60 seconds. Lewy used the method of mean error, which necessitated an adjustment of the comparison distance till it seemed like the same. This occurred after the time interval had expired. Consequently, in case the adjustment took a second, the time interval would have been stretched all the way from 100 to 20 per cent. of itself for the intervals from one to five seconds. As the writers used clangs rather than lines in their investigations, Lewy's objections to the use of clangs may be briefly noticed. In the first place he says that even with pure tones, harmonics can crowd into memory and disturb it. In the course of long experimentation with tuning forks, one of the writers has not found this to be the case. Lewy next objects, that by means of gentle "Mitsingen" the reagents would be able to fix the norm. The obvious answer to this is that the differences used in discriminative experiments are too small to be reproduced by singing. As Stumpf[4] says: "Would the most practiced singer venture to produce 90 different tones within the half-tone interval from h^1 to c^2? But this is the number of differences that can be detected by practiced ears." Lewy also found an increase of variable error with the time, in localizing points on the skin.

Some experiments by Paneth and Wahle, communicated by Exner, illustrate the contradictory condition of the memory

[1] J. Bigham: Memory. *Psy. Rev.*, Vol. I, p. 453.
[2] Münsterberg: Beit. z. exp. Psy., Vol. II, p. 163.
[3] Lewy: Unt'r'g ü. d. Gedächtniss, *Z. f. Psy.*, Vol. VIII, p. 231.
[4] Tonpsychologie, Vol. I, p. 163.

problems. Paneth[1] tried to reproduce a time interval by pressures on a key connected with a kymograph. As a result of 1,451 trials, he found that the "sharpness of the memory image" declined so little in the course of five minutes that the difference could not be measured by the method used. Wahle experimented with white disks on a black ground (surface magnitudes), and later with just observable differences of brightness. Exner does not give the details of these experiments—he simply says: "They were conducted with the same care and gave rise to the same negative results as Paneth."

The experiments of Baldwin and Shaw[2] and of Warren and Shaw[3] are not strictly to be compared with those of Wahle, as they obtained their data from 'class experiments,' carried out for much longer intervals (10, 20, 40 minutes), which were 'filled' with class work. In general, they found a decrease in accuracy of selection or identification with increase of time. In reproducing a given square, however, the class error for 40 minutes about equalled that for 20. In regard to this the authors say that the class may have been tired or the paper on which the squares were drawn, too small. In view of the contradictory results of various experimenters, it is perhaps also admissible to say that, under the conditions, a class could reproduce a given square as well after 40 minutes as after 20.

Other experiments of Münsterberg[4] as well as those of Smith[5] are not considered here, partly because they are serial, and partly because they have to do with questions of distraction, which will be discussed in the second part of this paper. We turn, therefore, to a closer examination of Wolfe's experiments.

The stimuli used by Wolfe were clangs from an Appunn 'Ton-Messer,' and they lasted one second, as nearly as the operator could pull the stop. For the experiments of the first of the two periods into which the entire work was divided, 5 different clangs were used to avoid the possible formation of a sense of absolute pitch. The time intervals between norm and comparison ran from 1 to 120 seconds—the greater part lying between 1 and 60 seconds. Intervals up to 30 seconds were marked by a metronome. In this connection it is curious to observe that metronome beats have been used sometimes as

[1] Paneth: Versuche ü. d. zeit. Verlauf d. Gedächtnisses. *Cen. Blatt. f. Phys.*, Vol. IV, p. 81. Mitgetheilt von Sig. Exner. Cited also by Lewy, S. 234.

[2] Baldwin and Shaw: Memory for Square Size. *Psy. Rev.*, Vol. II, p. 236.

[3] Warren and Shaw: Memory for Square Size. *Psy. Rev.*., Vol. II, p. 239.

[4] Münsterberg: *Z. f. Psy.*, Vol. I, p. 115.

[5] Smith: Attention and Memory. *Mind*. N. S., Vol. IV, p. 47.

a means of distraction, sometimes without being noticed, and sometimes with even the effect of fixing the attention on the regular stimuli.[1] It illustrates the complexity of the distraction problem that the same kind of stimulus should come to produce either fixation or distraction according to the attitude of the reagent. From the experiments of the first period with difference of 4 vibrations, as Wolfe himself says, not much is to be concluded, as the flight of time had but little effect in comparison with the uncertainty of the reagents in judging 'higher' and 'lower.' Perhaps the most pronounced result was that with no difference in vibrations between norm and stimulus ($\Delta=0$), the proportion of correct judgments was large with small time intervals, and fell off with increase in time. With $\Delta=8$, there was some, though not marked, increase of right judgments (r) over $\Delta=4$. In this case also r decreased with the time, though not so much as for $\Delta=0$. Similar results are found for $\Delta=12$.

In Wolfe's numerous experiments of the 'second period' 11 norms were used to avoid the formation of a sense of absolute pitch. These norms ran from 144 to 1,004 vibrations, giving opportunity, incidentally, to investigate the relation of liminal differences to pitch.

The number of reagents was 4—Wolfe himself acting at once as reagent and experimenter, giving far more judgments than any other reagent. For all reagents, and for all values of Δ, viz., 0, 4 and 8, there was a falling off in accuracy of judgment with the increase in time interval—the decrease being most marked for $\Delta=0$. Accordingly, the well known curves for tone-memory, together with the logarithmic law, are deduced from cases where there was no difference between norm and comparison.

The experiments of the writers were also performed on an Appunn 'Ton-Messer,' with the range of an octave, viz., from 512 to 1,024 vibrations with a difference of 4 between consecutive stops. The reagents were 4 in number—Mr. G. E. Libby, Mr. Wilson, Miss Steffens, and one of the writers (F. Angell). All could or would sing a little, but in Germany, at any rate, would hardly be regarded as musical. They sat with their backs to the instrument and ten (10) feet away from it. The matter of distance is not unimportant, as for a distance of less than a meter from the instrument reagents would be able to recognize a difference in the positions of two stops, differing by eight vibrations. Two of the reagents were unacquainted with the object of the experiments, and to this day three are unacquainted with the result. None of the reagents, during

[1] Wolfe: *op. cit.*, S. 530.

the course of the investigation, had the slightest information in regard to the results or the general trend of the experiments, nor were they aware of the differences judged. They were told to judge each pair of stimuli as if it was the only pair, and to beware of forming any theories in regard to the succession of norm and comparison. Of course they were to note anything in their judging which appeared to them noteworthy. On account of the variations introduced into the work by the experimentation on distraction, it was impossible to make use of a large number of norms. Accordingly, one of the three clangs corresponding to 540, 560, or 580 vibrations was used as *the* norm for a series of 10 judgments, and at the same time this norm might be varied 4 vibrations either way. Thus, in a series of 10 judgments the noun 560 might be raised to 564 or lowered to 556. In this way all danger of forming a sense of absolute pitch was avoided.

The reagents were told at first to judge merely "like or unlike," but before the practice period was over, they gave the judgments 'higher' or 'lower' without thought of "like or unlike." Accordingly the ratios of right and wrong cases in tables of for 'unlike' judgments are based on judgments of 'higher' and 'lower.' Doubtful judgments are divided proportionately between right and wrong judgments. The differences used were $\Delta = 0$, $\Delta = 4$, and $\Delta = 8$, but as the reagents knew nothing in regard to the size or variations of Δ, their attention was presumably equally strained for all of its values. Nine time intervals were investigated, viz., 1, 3, 5, 7, 10, 20, 30, 40, 60 seconds. Along with the experiments ran a series with distracted attention, the results of which are incorporated with the pure memory experiments for the sake of economy of space.

For each time interval about 90 judgments were given by each reagent with distraction, and 90 without. Of these judgments about ¼ were given on a difference $\Delta = \pm 0$, the remainder being almost equally distributed between $\Delta = \pm 4$, and $\Delta = \pm 8$. Table I gives the actual results of experimentation after practice, and Table II gives the percentage of right cases in Table I for each value of Δ. As will be seen from Table II, the falling off in accuracy where $\Delta = \pm 4$ or ± 8 is small. It is more marked in the case of A than of the others, though one finds that A with $\Delta = 4$ is as accurate for 60 seconds as for 5, and more accurate than for 40 seconds. S. on the other hand shows greater accuracy in judging these differences for the longer time intervals. For $\Delta = 8$ her average per cent. for the 4 shortest intervals (1 to 7 seconds) is 56: for the 4 longest intervals (20 to 60 seconds) it is 59. For $\Delta = 4$ the difference is still more marked, the average for the first 4 intervals being

TABLE I.

Actual number of right (r), wrong (w), like (111), and doubtful (?) judgments for each of the four reagents, L., W., A., S., for each time-interval (t-i) and for each difference (Δ) of 8, 4 and 0 vibrations, with and without distinction (D).

LIBBY.

t.-i.		1		3		5		7		10		20		30		40		60		
			D		D		D		D		D		D		D		D		D	
Δ=±8	r	56	52	37	39	36	34	36	28	40	38	43	34	39	41	33	30	29	29	
	w	1		2			1				2	1	1	3	3	1	6	4	5	
	111	2		1	1									2		2	1	1	1	
	?	1					1					1						1		
		60	52	40	40	36	36	36	28	40	40	44	36	44	44	36	36	35	35	total= 718
Δ=±4	r	18	26	31	34	37	38	32	45	32	34	29	36	26	30	28	28	26	30	
	w	1	2	4	3		4	4	3	1	3	5	6	7	5	6	7	7	4	
	111	1		7	3	7	2	7	3	5	3	2	2	1	1	3	1	2	1	
	?	1						1		2				2				1	1	
		21	28	42	40	44	44	44	51	40	40	36	44	36	36	37	36	36	36	total= 691
Δ= 0	r	19	16	16	12	14	3	10	5	11	2	6	1	5	1	6	0	2	1	
	w	1	4	4	8	6	17	10	15	9	18	14	19	15	19	12	18	16	17	
	?																			
		20	20	20	20	20	20	20	20	20	20	20	20	20	20	18	18	18	18	total= 352

Total judgments for L.= 1,761

WILSON.

t.-i.		1		3		5		7		10		20		30		40		60		
			D		D		D		D		D		D		D		D		D	
Δ=±8	r	54	41	36	36	35	29	33	24	38	36	40	31	37	34	32	29	29	29	
	w	6	10	3	3	1	6	3	2	2	4	4	7	5	9	2	7	5	7	
	111		1	1					1					2	1	1		2		
	?				1											1		1		
		60	52	40	40	36	35	36	27	40	40	44	38	44	44	36	36	37	36	total= 721
Δ=±4	r	14	22	28	26	22	30	36	34	26	27	23	32	27	26	24	22	24	20	
	w	5	4	7	12	15	12	3	14	9	11	12	10	7	7	6	8	8	11	
	111	1	2	4	1	6	2	5	4	5	2	1	2	1	2	5	4	3	1	
	?			1		1								1	1	1	2		4	
		20	28	40	39	44	44	44	52	40	40	36	44	36	36	36	36	35	36	total= 686
Δ= 0	r	19	16	17	14	18	12	15	12	17	9	11	8	11	3	7	9	3	5	
	w	1	4	4	5	2	8	5	7	3	11	9	12	8	13	11	10	14	10	
	?										1			3	2			1	2	
		20	20	21	19	20	20	20	19	20	21	20	20	22	18	18	19	18	17	total= 352

Total judgments for W.= 1,759

TABLE I.—(*Continued.*)

ANGELL.

t.-i.		1		3		5		7		10		20		30		40		60		
			D		D		D		D		D		D		D		D		D	
Δ=±8	r	51	44	33	33	29	27	27	22	31	30	30	30	34	33	30	26	26	26	
	w	3	1					2				1		2		3	1	3		
	III	2	1	1	2	1	4	3	1	3	1	3	4	2	3	3	3	1	8	
	?		2	2	1	2	1		1	2	5	2	2	2	4		4	6	2	
		56	48	36	36	32	32	32	24	36	36	36	36	40	40	36	34	36	36	total= 662
Δ=±4	r	10	17	25	14	19	16	24	29	21	22	22	21	20	17	16	15	18	18	
	w	1		1	1	3	2	2	5	3		1	2	3	2	5	7	6	5	
	III	4	7	8	19	11	15	14	14	11	10	9	9	8	9	12	9	8	10	
	?	1		2	2	3	3			1	3	4	3	1	4	3	3	3	2	
		16	24	36	36	36	36	40	48	36	35	36	35	32	32	36	34	35	35	total= 618
Δ= 0	r	14	16	18	14	15	9	15	11	15	11	14	7	12	7	9	5	5	6	
	w	2	2		3	1	6	3	6	3	4	4	6	4	10	8	9	12	8	
	?	2		1		2	3		1		3		5	2	1	1	4	1	3	
		18	18	19	17	18	18	18	18	18	18	18	18	18	18	18	18	18	17	total= 160

Total judgments for A.= 1,440

STEFFENS.

t.-i.		1		3		5		7		10		20		30		40		60		
			D		D		D		D		D		D		D		D		D	
Δ=±8	r	34	32	23	27	17	14	25	19	21	20	20	14	23	25	18	20	22	19	
	w	25	20	15	13	19	21	11	9	15	18	16	17	17	15	16	10	13	17	
	III						1					1	1							
	?			2												2	2	2		
		59	52	40	40	36	36	36	28	36	38	37	32	40	40	36	32	37	36	total= 691
Δ=±4	r	9	16	18	19	17	19	25	30	18	17	19	26	18	18	23	15	19	25	
	w	9	10	24	18	27	24	17	19	17	17	13	13	14	14	13	15	15	10	
	III	2	2	2	1				1	1	2						1			
	?				1		1	1	1			1					1	1	1	
		20	28	44	39	44	44	43	51	36	36	33	39	32	32	36	32	35	36	total= 660
Δ= 0	r	18	12	12	5	7	5	8	2	7	3	1	1					1	1	
	w	2	8	8	14	13	15	12	18	11	14	17	16	18	18	18	15	17	17	
	?				1						1		1				1			
		20	20	20	20	20	20	20	20	18	18	18	18	18	18	18	16	18	18	total= 338

Total judgments for S.= 1,689

TABLE II.

Percentage of right judgments in Table I.

		t.-i. 1	3	5	7	10	20	30	40	60
LIBBY.										
Δ=±8		94	93	100	100	100	97	89	92	84
	D	100	98	95	100	95	96	93	85	83
Δ=±4		88	74	84	74	83	78	75	76	74
	D	93	85	82	88	85	82	83	78	87
Δ= 0		95	80	70	50	55	30	25	35	10
	D	80	90	15	25	10	5	5	0	5
WILSON.										
Δ=±8		89	90	97	91	95	91	84	80	78
	D	79	91	85	89	90	81	77	78	80
Δ=±4		70	71	51	82	65	64	76	68	68
	D	79	67	68	65	68	73	74	64	60
Δ= 0		95	85	100	93	85	55	57	45	18
	D	80	70	60	63	45	40	25	55	40
ANGELL.										
Δ=±8		91	94	94	84	89	86	88	83	79
	D	94	93	87	94	90	86	88	82	75
Δ=±4		66	72	57	60	60	66	64	49	57
	D	71	42	49	60	67	63	59	44	56
Δ= 0		83	95	89	83	83	78	72	53	31
	D	89	94	58	64	69	53	39	39	42
STEFFENS.										
Δ=±8		58	60	43	63	57	59	60	50	68
	D	66	67	40	73	51	45	61	67	58
Δ=±4		50	41	40	53	50	59	56	64	57
	D	57	50	43	60	47	66	56	48	71
Δ= 0		90	60	35	40	35	5	0	0	5
	D	60	28	25	10	18	8	0	3	5

46: for the last 4 it is 59. L. and W. held an intermediate place between S. and A. in this respect. As far as these results go, therefore, no law can be laid down in regard to a decrease in accuracy of the so-called tone-memory for intervals up to 60 seconds: the most that can be said is that there is a small and irregular falling off for some and no falling off for others. In this respect, then, our results are different from Wolfe's.

On the other hand there is a very marked falling off in accuracy of judgment with increase of time interval for $\Delta = 0$: in the case of S. the percentage of right judgments sinks from 90 for 1 second to practically zero for the longer time intervals. With A., however, the corresponding figures are 83 and 31 respectively, indicating, it would seem, less a marked difference in sensitivity than a marked difference in method of judging. Before proceeding to an analysis of results the writers will add Tables III and IV similar to Tables I and II respectively.

These tables are results of experiments carried out the following year with two new reagents, Mrs. Mary George and Mr. Bullock—as a test of the results in Tables I and II. And here it may be said that both series of experiments were conducted under very favorable circumstances; no other experiments were allowed to go on in the laboratory at the same time; the laboratory building itself was situated in a field with but one occupied building in its vicinity. Finally, the reagents themselves were all earnest and strenuous. The conditions of the

TABLE III.

Second group of Reagents. Symbols as in Table I.

GEORGE.

t.-i		1		3		5		7		10		20		30		40		60		
			D		D		D		D		D		D		D		D		D	
Δ=±8	r	20	20	18	21	20	22	21	19	36	35	52	48	52	43	39	31	38	37	
	w	2	4	3	2	1	1	2	3	3	4	2	8	3	5	6	10	6	8	
	III				1	2	1	1	2	1	1	2	2	1	8	3	7	4	3	
	?	1		1		1														
		23	24	22	24	24	24	24	24	40	40	56	58	56	56	48	48	48	48	total= 687
Δ=±4	r	13	14	19	16	18	16	15	16	42	39	55	54	58	44	45	45	47	52	
	w	6	8	3	6	4	5	5	4	15	19	15	15	21	26	18	16	22	13	
	III	3				2	3	3	3	15	16	17	17	11	18	17	19	10	15	
	?							1	1											
		22	22	22	22	24	24	24	24	72	74	87	86	90	88	80	80	79	80	total=1,000
Δ= 0	r	9	6	10	6	7	5	6	3	15	12	11	10	14	9	15	12	10	12	
	w	3	6	2	6	5	7	6	9	13	16	25	26	22	27	17	20	22	20	
	?																			
		12	12	12	12	12	12	12	12	28	28	36	36	36	36	32	32	32	32	total= 424

Total judgments for G.=1,211

BULLOCK.

t.-i.		1		3		5		7		10		20		30		40		60		
			D		D		D		D		D		D		D		D		D	
Δ=±8	r	17	17	22	16	21	20	19	21	34	27	42	45	50	39	40	37	36	35	
	w	3	1	2	1	2	1	1	3	1	6	10	5	4	11	3	5	11	9	
	III		1		2	1	3	4		5	7	4	5	2		5	5	1	2	
	?		1		1								1				1		3	
		20	20	24	20	24	24	24	24	40	40	56	56	56	50	48	48	48	49	total= 671
Δ=±4	r	17	17	17	18	17	16	16	19	33	31	43	48	59	41	54	40	46	37	
	w	4	3		1	1	4	3	2	12	11	17	15	8	19	12	8	13	14	
	III	1	2	5	3	6	2	5	3	11	13	9	8	5	18	6	13	3	12	
	?						2				1	1	1				3	1	1	
		22	22	22	22	24	24	24	24	56	56	70	72	72	78	72	64	63	64	total= 851
Δ= 0	r	12	10	12	9	8	7	8	6	20	15	16	14	17	17	13	10	13	14	
	w		2		2	4	5	4	6	4	9	16	16	15	14	4	16	14	11	
	?				1											1	2	1	3	
		12	12	12	12	12	12	12	12	24	24	32	30	32	31	28	28	28	28	total= 381

Total judgments for B.=1,903

TABLE IV.

Percentage of right judgments in Table III; about three times as many judgments for intervals from 10 seconds to 60 seconds as for intervals 1 second to 7 seconds.

GEORGE.

t.-i.		1	3	5	7	10	20	30	40	60
$\Delta=\pm 8$		88	84	85	87	90	93	93	81	79
	D	83	87	91	79	87	86	77	65	78
$\Delta=\pm 4$		59	86	79	64	58	63	64	56	60
	D	64	73	66	69	53	63	50	56	65
$\Delta=0$		75	83	58	50	54	30	66	47	31
	D	50	50	42	25	43	28	25	37	37

BULLOCK.

t.-i.		1	3	5	7	10	20	30	40	60
$\Delta=\pm 8$		85	92	87	79	85	75	89	83	75
	D	88	83	83	87	68	81	78	78	75
$\Delta=\pm 4$		77	77	71	67	59	62	82	73	74
	D	77	82	71	79	56	67	52	65	59
$\Delta=0$		100	100	67	67	83	50	43	75	48
	D	83	79	58	50	62	47	55	39	47

experimentation were as in the first group—the reagents being kept in complete ignorance of its course. The chief difference lay in the methods of distraction and in increasing the relative number of judgments for the longer intervals—from two to three times as many judgments being given on the intervals from 10 seconds to 60 seconds as on those from 1 second to 7 seconds.

The results of these experiments corroborate those of the preceding group: as before, in agreement with Wolfe, there is a marked falling off in right judgments with lengthening time for $\Delta = 0$:—on the other hand there is no marked and regular falling off with the time for $\Delta = \pm 8$ or $\Delta = \pm 4$. Comparing the longest with the shortest intervals one gets:—

		Average of four intervals 1 sec. to 7 secs.	Average of four intervals 20 secs. to 60 secs.
George	$\Delta=\pm 8$	84	84.5
	$\Delta=\pm 4$	72	60.7
Bullock	$\Delta=\pm 8$	85.7	80.5
	$\Delta=\pm 4$	73	72.7

If G. shows a falling off for the longer intervals with $\Delta=\pm 4$, she shows none for $\Delta=\pm 8$. B. on the other hand shows a falling for the greater difference, but practically is as accurate on the longer interval as on the shorter for the smaller differ-

ence. So far as these results go, there can be no general law of sensory memory.

Even for $\Delta = 0$ the individual variations are far too great to admit of other than the very broad statement that the number of correct judgments decreases with the time interval.

The writers are not able to explain satisfactorily the discrepancy between Wolfe's results and their own. The main difference is perhaps that in Wolfe's work the reagents knew what the value of Δ was which they were judging:—whether it was a difference of 4, 8 or 12 valuations—while in the writers' work none of reagents knew anything in regard to the value of Δ. This difference in the mental attitude of the reagents is reflected in the results, as Wolfe's reagents did not respond to variations in the value of Δ as closely as one would have expected. Wolfe himself is of the opinion that with the greater differences the attention was less strained—whether during the action of the stimuli or during the time interval he does not specify.

Acting at once as reagent and experimenter, Wolfe contributed to his data far more judgments than any other reagent, but we do not find that his general results differ so much from those of the other reagents as to warrant the inference that his knowledge of the course of the experimentation affected the work very differently from the knowledge of the other reagents.

A further difference between Wolfe's method and our own lies in the fact that in our work the number of judgments for $\Delta = 0$, was about $\frac{1}{3}$ of those for $\Delta = \pm 4$, or for $\Delta = \pm 8$, while in the earlier work the number of judgments for $\Delta = 0$ was greater than for the other differences. When one considers the diversity of results produced by different mental attitudes, together with the great difficulty of reproducing accurately all the conditions under which a given set of psychological experiments is made, one is almost tempted to say that it is likeness of result, not unlikeness, which calls for explanation in work of this kind.

As far as the writers' results go, however, there is no question of a loss of sensory memory: the individual variations are so great in both groups of experiments as to indicate that we have to do with certain specific ways of forming judgments rather than with a general way of depending on the presence of a more or less fleeting 'memory image.'

The discussion of the 'memory image' theory in the light of the distraction experiments, together with a consideration of specific ways of forming judgments of like or unlike, will occupy the second part of this paper.

(Part II to follow.)

NOTES ON THE PSYCHIC DEVELOPMENT OF THE YOUNG WHITE RAT.

By WILLARD S. SMALL, Fellow in Psychology, Clark University.

A study of the psychic development of any young animal needs no apology. Apart from the fascination and the self-education of watching the development of any form of life from its early protoplasmic simplicity into complex maturity, there is the solid scientific reason that Genetic Psychology has much to hope from minute and accurate records of the developmental periods of young animals of all species. It may never be possible to reconstruct a complete psychic organism from the evidence of a single trait—an ideal borrowed from morphology—but something surely may be accomplished towards a *comparative embryology* of the soul. What Preyer and others have done for the human infant, needs to be done also for the baby-animal of every species. Prof. Wesley Mills, of Montreal, has already done this for the dog, cat, rabbit, guinea-pig and chick—which latter has also received careful study from Spalding, Morgan, Thorndike, Kline and others.

The present form of this study was suggested to me by Prof. Mills's very interesting and attractive work. I have adopted his method of giving the diary of the first few weeks of the young animal's life, substantially as the notes were jotted down, following this with a general summary of results and some in ferences as to the significance of special features. For this purpose one litter of five rats was carefully observed daily, from birth to the age of four weeks. For study of special points and confirmatory evidence other litters were often used.

From a physiological point of view the developmental period of the human organism[1] falls into two great divisions—before and after puberty—the *ante* and *post urbem conditam* of growth. The pre-pubertal period is childhood. But this again is divided, upon physiological and anatomical grounds, into two periods, infancy (das eigentliche Kindesalter, infantia, enfance) and childhood proper (das Knabenalter, pueritia, jeunesse). Without pausing for the anatomical characters upon which this division is based, it is perhaps a fair statement to say that infancy is the period in the child's life before the neuro-mus-

[1] Vierordt: Gerhardt's Lehrbuch der Kinderkrankheiten, B. I, Ab. I, p. 299.

cular system and the sensory apparatus have reached a stage of development when they function easily and definitely. The period after that, and before puberty, is childhood.

In all the higher mammals, at least, there are analogous periods of development. Doubtless there are wide variations in the distributions of these periods, even between closely allied families as, *e. g.*, the guinea-pig and the rat. The guinea-pig's infancy is almost wholly intra-uterine,—he is born with neuro-muscular and sensory apparatus almost perfectly developed. The rat, on the other hand, does not reach a like degree of development until about the third week of life, or even later.

The diary covers the period of infancy of the white rat, *i. e.*, the period up to the time when the sense organs were working normally, and the muscular movements were all perfectly co-ordinated. The subsequent period has received only casual observation. The summary and inferences have the supplementary evidence of general observations covering a period of nearly two years.

Day 1. The rats at birth are bright red, ugly and helpless little creatures. The average weight is 5 grams. Average length: of body, 4.2 cm.; head, 1.2 cm.; tail, 1.4 cm. The skin is thin and delicate, and absolutely destitute of hair. There is no external ear—only a dermal fold. No external eye—a slight protuberance. The nose is pretty well developed—a spongy-looking bulb, armed with short delicate feelers. The nostrils are completely open, but very small—about ½ mm. in diameter. Mouth is a mere sucking disk. No rudimentary teeth. Their movements, except sucking, are inco-ordinated, yet purposive. Sucking they accomplish lying on their backs and sides, the mother crouching over them. They keep constantly under the mother's body. When held in the hand they roll up in a ball. If placed upon their backs they hitch and kick and wriggle over upon the belly or side. They are generally unable to maintain the belly position for any length of time and fall over upon their sides in a ludicrous manner. When lying upon the belly, they stretch out their paws in a turtle-like way. Move their tails.

I distinguish three vocal efforts: a sort of clucking sound; a fine wire-like squeak (hunger?); and a sort of chirp, short and sharp.

I tested for reactions to smell, taste, and tactual stimuli.

Smell. 5 rats. All sensed violet, as indicated by expressive movements. Reaction, slow—about 15 seconds. One only objected: threw up head and made convulsive movements with fore paws. All showed dislike to cheese, if movement away could be so interpreted. Instantaneous convulsive reaction to HCl.

Taste. Tested with sugar-solution, warm milk, and strong salt solution. These were applied to lips with fine brush. In each case, the rats squeaked and wiped at the offending stuff with fore paws. Movements rather inco-ordinated. The movements are: brushing and pushing away with the fore paws; averting the head; movement of the whole body. In case of the salt solution, the reactions were more vigorous, accompanied by voiding of urine.

Clear water called out the same characteristic reactions.

From this similarity of response, I infer that there is no differentiation of tastes, as pleasant and unpleasant. They are all unpleasant.

Temperature. (a) They are very sensitive to atmospheric changes. Removed from the nest into a temperature of about 45° F., they become torpid; heart-beat becomes markedly slower and fainter. (b) They have temperature sense, though they do not respond to moderately hot or cold stimuli; a hot wire, just below burning point, makes them jump and wriggle within the skin; cold (water) above 40° F., gave no result unless accompanied by pressure.

Pain. They respond with squeaking and struggling to slight pinching.

Tactile Sensibility. They give little response to light pressure, as with a hair—except upon the nose, which seems to be very sensitive. Mass pressure is not noticed unless comparatively strong. All attempts to get response to sound failed—as expected.

Day 2. Repetition of the same measurements showed growth. Ear and eye regions a little more prominent. Seems to be slight advance in sense of smell, for they made no objection to odor of cheese. Other odors elicited same responses as first day.

Day 3. The movements are a little better co-ordinated. Only one of the five showed aversion to violet, and two to clove and asafœtida. Spirits of camphor and pennyroyal brought expressions of disapproval from all. Irritating fluid (HCl.) produced instantaneous responses from all. In addition to the motor reactions, there were vocal expressions and a striking acceleration of respiration. Reactions to the other stimuli were slow, varying from 10 to 50 seconds.

Day 4. The skin begins to whiten a little. Dermal sensibility seems about the same. Movements are better co-ordinated. When placed upon their backs, they turn over much more quickly and surely. Maintain position upon the belly. Are able to crawl a little, and to raise the head higher and longer than yesterday. They constantly utter short metallic squeaks and the clucking noises, during these efforts to recover equilibrium and orientation—for I take these attempts to raise themselves to be the prophecy of the orienting process. They huddle together—trying to crawl under each other. They make an animated pile. This is a characteristic habit of the rat throughout life. A company of rats will always pile up in a dense heap except in the warmest weather.

Smell. Reactions to violet, camphor, pennyroyal and clove, show less aversion; those to asafœtida are quicker and show more dislike. In four cases out of five there seemed to be a pleasurable response to cheese-odor—in one case accompanied by what sounded like a pleased squeak. The fifth one paid no attention. In case of camphor and pennyroyal, it was easy to distinguish between the act of sensing the odor and the affective response. They sensed pennyroyal quickly—about 5 secs.—sniffed with deep respiration—then slowly averted the head.

Day 5. Much stronger. Turn over almost instantly when placed upon back. Crawl with considerable vigor.

It begins to be apparent that the clucking sound spoken of several times before, is the beginning of a squeak—other than the one they make in the nest when hungry and which they make from birth. This new squeak is solider in timbre—a short, sharp, metallic click—something like the chirp of a sleepy chicken. It is evidently a sign of pain or discomfort. The other seems to indicate hunger.

Nothing new in regard to the special senses.

When returned to the cage they began immediately to crawl about in a lively manner. This is an infant prophecy of that restless curiosity which is so prominent a characteristic in the rat nature.

Day 7. Weight, 8.8 gr. A gain of 3.8 gr. Length: body, 6 cm.; head,

1.7 cm.; tail, 2.5 cm. The skin is now plainly covered with tiny white hairs. The ears, eyes and nose show commensurate progress. The pinnæ are 3 mm. in length; the invagination of the meatus begins to show. The membrane over the eye-bulbs is white, but shows a dark line where the separation of the lids is to be. There are a few brow-hairs started. The nostrils have doubled in diameter. Feelers have more than doubled in length.

When placed upon their backs, they instantly turn over. Rest quite firmly upon their limbs, which are spread out in a turtle-like manner. Crawl vigorously.

Dermal sensibility becomes more acute, though susceptibility to pressure is still greater on the nose than elsewhere on the body. Especially, greater when tickling is involved. A bristle drawn across the body elicits scarcely any response; but applied with the same pressure to the nose, evokes squeaking and vigorous head-shaking. When the toes are touched the rats squeak and jump so as to lift the body nearly off the floor. One, thus insulted, crawled away two inches. There seems to be a slight intensification of the reactions to painful stimuli. I notice occasional convulsive leaps which have no apparent external cause. The tests for smell seem to show a growing indifference to all but the positively painful stimuli—irritating fluids, *e. g.*, HCl.

Day 8. Crawl vigorously. They almost crawled out of my hand before I realized what they were doing. In constant motion while on the table.

The nostrils begin to take on the pear-shape. Lower teeth can be seen in the gum, but are not cut.

When crawling about the table they show some selection of path, sniffing and going in different directions.

They seek constantly to get close together, each striving to get under the rest for warmth. This action is very striking.

Two crawled to the edge of the table, but stopped and then crawled away. Another one got too near, lost his balance and fell over. Another went to the edge and remained there with his head just over. This looks like a sensing of danger.

Reactions to odors become more individual. On the whole they tend to become indifferent. Glacial acetic acid and carbolic acid gave negative reactions.

Day 9. Pinnæ are 4 mm. long. Meatus deepening. Covering membrane of the eyes is now very thin, and shows dark purple in contrast with the surrounding white-haired region.

The motor activities are stronger. They move forwards, backwards, and sideways. Climb into a heap. One crawled more than a foot, stopped, hesitated and finally came back. They sniff constantly at everything. They crawled out of the nest after the mother had put them in. Saw one seeking purposively for her teats.

Day 10. Nostril is now perfectly pear-shaped. Feelers about 1 cm. in length. Mouth is assuming the adult form—the upper lip has the deep sinus.

Activities are stronger, better co-ordinated and more constant.

Special senses show no new features.

Day 11. Meatus-indentation shows corrugation.

Day 12. Lower teeth are cut.

Mother was at opposite side of the cage from the nest. One of the young ones crawled across to her and began to suck. He seemed to have a definite purpose. Later I saw the same one trying to crawl up the perpendicular side of the cage—wood covered with wire mesh. Got up about three inches before falling. A few minutes later he climbed

upon his mother's back. (N. B. Eyes not open.) They *walk* now, though rather unsteadily. By using both fore and hind feet they held to my hand a moment when I suddenly turned my hand half over. They also crawled out of my hand when it was gently closed upon them. A very characteristic action. Rats always squeeze through crevices if confined. I saw one washing his face—the real thing. Licked the paws and then carried them over the face. Repeated half a dozen times. Movements are not very well co-ordinated. Three crawled to the edge of the table, stopped, reached over as far as possible without falling, throwing up the head and sniffing in the very characteristic way of rats when orienting themselves, and then retreated. One leaned a little too far over, and fell, but caught the edge with fore paws and hung a moment till I saved him.

Dermal sensibility considerably heightened. One jumped violently when touched with the sharp corner of a piece of paper. Flanks, sides, back and feet are equally sensitive. (Possibly fright accounts for this violent reaction. But why fright, unless there is increased sensibility?)

Day 14. Weight, 14.8 gr. Length: body, 7.1 cm.; head, 2.2 cm.; tail, 3.9 cm. The pinnæ are about 6 mm. in length; the conch is pretty well formed, and about 2 mm. deep. Ears and eyes appear ready to open. Feelers are 1.5 cm. long. The upper teeth are cut. The body is covered with hair about 3 mm. long on back and sides; shorter on the belly and legs. Ears and tail quite bare.

They run about the cage and over the mother's back. Climb over considerable obstacles. One got down from a block two inches high without falling. Hold on to the finger a second when turned upside down. All wash their faces industriously. When moved to a new place they go through the peculiar orienting movements of rising upon hind legs (as far as their deficient strength permits), lifting their heads and sniffing. They show the same proneness to pile up in a heap, when left loose upon the table. I notice also the convulsive starts, with no apparent external stimulus.

Sensibility is heightened, as indicated by convulsive reactions to tickling and light pricking. They sense odors at a much greater distance now. The same actions when they come to the edge of the table.

In their appearance and actions they now begin to answer to Dehne's characterization of "lieblichste Thierchen."

Day 15. Ear appears perfect, but is not open yet. So the eye.

They wash their faces frequently. Saw one scratch the back of his head and face with his hind foot. Romanes says this action is a pure reflex.[1] These movements were all perfectly co-ordinated. While I was weighing them, one fell out of the scale pan. He caught the edge as he went over and hung by his fore paws for more than a minute, struggling to get back, which he nearly succeeded in doing. A great increase in strength.

One of the rats crawled from the top of one cage down to another two inches below. The top of the first cage was walled in on two sides by glass sides, but at the corner where they met was an aperture about one inch wide.

The rat was crawling along the top of the box close to the glass side. When he came to the end he poked his nose through the aperture, discovered the descent, leaned far out and sniffed; tried to retreat, but, finding this difficult, sniffed carefully down the side, then went down without falling. Crawled an inch or two on the top of this cage,

[1] Darwin and after Darwin. Part II, p. 80.

then turned and came back the same way, climbing up over the first cage. (It is to be remembered that the rat's eyes were not open at this time.) The mental movement involved is not easy to interpret. One might speculate profusely. Whatever may have been the cause of his turning back, it seems probable that he took the straight path back by scenting his own trail.

Day 16. Ears and eyes not yet open.[1] The mother has roofed over the nest, and has a small hole for exit and entrance. I saw one of the young one's nose around until he found the hole and then crawl out. They can cling to the finger more than a minute when held upside down. They give no sign of fear when I handle them. They lie in my hand perfectly content.

Day 17. All have ears open and the eyes of all but one are wholly or partially open. (The eyes and ears of another litter opened on the fifteenth day.) This simultaneous opening of two new sense avenues must mark a crisis in the life of the rat. The voluntary motor activities noted are: crawling all over the mother while in the nest; frequent face-washing; occasional scratching of the head with hind foot; one nibbled at my finger as I held him in my hand; one crawled hastily out of the nest when I put my hand in to get them.

When being weighed, they crawled to the edge of the scale pan and peered over, but did not try to get out. I notice distinct tail movements. They now lie contentedly in a compact row instead of piling up indiscriminately. I am led to ask whether these huddling movements are not the first expression of the social instinct (after sucking and seeking the mother's belly for warmth). If so the desire for warmth is *a* primitive root of the social consciousness.

The rats now walk firmly and orient themselves quickly. I saw one chewing for several minutes, as if sucking or trying to swallow, as he lay half asleep. Is it a reflex exercise anticipating mastication? A play?

Sensation. Hearing. The bursting of a bag three feet away caused them to jump quite out of the nest. Later, clapping hands sharply at a distance of 10 feet caused the quick recoil peculiar to rats. Did not run. A sharp "sh" at 3 ft. brought their heads up. Word "rats" in a low tone at 1 foot, caused a slight jump. Rustling of paper produced the same result. Whistling brought up the head as if listening. Even at the very dawn of ear-consciousness there seem to be differences of emotional reaction to different elements in the "big buzzing confusion" around them. Every concussion elicits a startled movement; the gentle, prolonged note, *e. g.*, whistle, on the contrary, produces a reaction indicative of unscared attention.

Sight. When brought into a strong light they did not wink or show uneasiness, though they soon closed their eyes, and seemed to become drowsy. A stroke of the hand one inch in front of the face caused winking and a slight recoil of the head.

Smell. Recoiled quickly from camphor. Moved quickly toward brown-bread, dog-biscuit, and honey held at a distance of one inch. Appeared not to dislike iodoform or wintergreen.

Taste. One ate honey when a drop was put into his mouth. Tried to gnaw brown-bread when a crumb was put into his mouth. After that when the brown-bread came within smelling range he would go towards it. Chewed a tiny piece, holding it in his paws in a well-bred rat's way. I gave a little piece to another one. He took it in both paws and chewed it. The others scented it and tried to help, but he

[1] Another litter, having the eyes open already on the sixteenth day, lapped milk from my finger after having been given a taste of it.

quickly drew away with his treasure. There seems to be an immediate association between smell and taste. Though not conclusive, the evidence points that way. Another one declined to eat sealing-wax after smelling it, and spat it out when a piece was put into his mouth.

Emotion. They show fear, as before stated, when touched suddenly; also at a loud concussion. I cannot see that they have any fear of me, certainly not from smelling me. They looked happy when eating brown-bread.

Day 18. Eyes of all fully open. All the movements are stronger and are pretty well co-ordinated. They are sprightly and characteristically restless. They sit up well on their hind legs, using the tail for support, and wash their faces vigorously, passing the paws quite to the top of the head. (N. B., the first washings were almost farcical—the paws often not touching the face more than one stroke out of three.) One licked and gnawed at my hand as he sat in it. I put my finger near his nose. He sat up, took it in his fore paws and chewed at it.

They constantly run about the cage and cause the mother great anxiety by getting out of the nest after she puts them in. I saw them hiding, apparently, in the loose excelsior of the nest. This is the first thing I have seen that looks like play. They crawl all over the mother.

Their sense of equilibrium is pretty good. One crawled from one scale pan across to the other. The distance is about 2 inches, and the bridge not more than ¼ inch wide; and the two parts were oscillating at that. Yet he made the journey safely.

They begin to show the characteristic curiosity of rats—investigating with the nose everything they can reach. They jump occasionally without apparent stimulus.

I saw one licking another's face. Probably a play activity? Or it may be an instinctive outcrop of that reciprocal service of washing or vermin catching which rats perform so habitually.

Sensation. Hearing, acute. Convulsive movements follow clucking, "sh"-ing, clapping of hands and other sudden noises. Whistling causes only wiggling of ears.

Sight. Wink when any object is brought close to their eyes. When in a strong light they soon become drowsy.

Smell. Sensed moistened dog-biscuit at 4 inches. Sniffed at pure cologne water. This odor seemed to disturb them for they crawled about nervously for several minutes.

Taste. They chewed bits of moistened dog-biscuit with evident relish. Seemed to like sugar, but did not touch it until it was put into their mouths. The grittiness disconcerted them a little, but the pleasure of the taste seemed to compensate. Salt did not cause much disgust.

Emotion. They show fear at unusual noises. No fear of me. They lie contentedly on my hand, and are not afraid when I take them up. Stroking their heads has a soothing effect. They seem to get the greatest satisfaction from lying huddled together.

Day 19. Incessant activity after 4 P. M. Play with the excelsior of the nest; run over the mother and each other.

Gnawed at a big piece of dry dog-biscuit when I fed the mother.

They are still absolutely fearless with respect to me.

Day 21. Weight, 18 gr. Length: body, 8 cm.; head, 2.5 cm.; tail, 5 cm. In 3 weeks they have nearly quadrupled in weight, and doubled in length of body—tail quadrupled—head doubled. The mother escaped from the cage last night, so the young ones have not been suckled to-day. They huddled together quietly most of the day, but towards night

began to run about and play. I saw one drinking at the water jar. All ate hard biscuit, and lapped milk from a little jar as they sat in my hand.

Whenever I go near the cage they stretch up their heads and sniff all about. I put my hand into the cage, near the nest, and they all crawled into it and licked and nibbled my fingers. Not the slightest sign of fear.

They now go all over the cage—up the sides and crawl on the roof, belly upward. One went from the outside top of the cage down into the inside—a feat requiring very perfect muscular co-ordination.

They still prefer mother's milk to artificial food, as indicated by insistence on sucking the moment she returned to the cage.

They begin to chase and pommel each other. Saw one tugging at the tail of another.

Day 22. The sense organs are now perfectly developed. There is merely a continuous growth. Feelers, 2.5 cm. Hair varies from about 1 cm. on the back to less than 1 mm. on the ears and tail.

Activities. They play almost constantly while awake. Climb upon the mother and playfully bite her ears. Wash themselves a great deal. Are very neat. Wash the whole body and bite the toe nails. I saw one, this morning, digging very vigorously at the corner of the cage. He had dug away all the sawdust for the space of an inch. According to Groos's interpretation this would be a play activity. It would be interesting to know whether the rat was *trying to dig out* or *was merely digging*.

Emotion. Still show no fear of me. They crawl fearlessly into my hand and thence over my coat. One crawled from my shoulder into my pocket and remained there. Fear in connection with loud noises is more definitely determinable: besides the reflex recoil, they crouch and huddle together and wear a subdued expression.

Their curiosity is inordinate. It seems greatly to predominate over fear—in striking contrast with the adults where the balance is pretty evenly preserved.

They come towards me whenever I open the cage. I am not quite sure whether they see me approaching, but I think they do.

They sleep most of the day, and still suck a good deal.

Advancing intelligence was marked to-day by a rat's pushing a comrade away from the dish of milk. The stimulus to this action might have been the odor or it might have been seeing the other fellow drink. The movement was very effective. Intelligence in this case at least is a "means to nutrition."

Day 23. The plays become a little more definite. The rats nip each other's tails, ears and feet. No real scrimmages as yet. They also lick each other—as if affectionately fondling each other.

The mother was returned to the cage after an absence of 24 hours. The little ones all left a dish of warm milk and hastened to suck. They exhibited the greatest satisfaction in the change.

Something to-day that looked like imitation. The mother was sitting in the nest, pulling excelsior towards her to build up the nest. One of the little fellows suddenly began doing the same thing. Stopped when the mother stopped.

They also began trying their teeth on the wood of the cage to-day.

Day 24. They now struggle for food. Begin to show the greedy eagerness which is a marked characteristic of the adult rat. I saw one scuffling with the mother for a piece of biscuit.

One ran and hid behind the mother when I put my hand into the cage. I have not seen, before this, any show of fear at the sight of my hand—or was it play—mere pretence?

They have fierce sham fights, tumbling, rolling and leaping about, but I have not seen any display of anger. They come to the window when I tap on it; and stand in attentive attitude after the reflex recoil at the sound. They dig into the corners of the cage a great deal. I also observe them "picking" the mother and each other a great deal. This seems to be recognized as a reciprocal office, for they sit quietly while it is being performed. Vermin?

Day 25. Play is very vigorous. They frequently start and leap without the least external stimulus—apparently the mere discharge of superabundant motor impulse. Frantic rushes up the side of the cage. They fight beautifully for food, but no sign of anger.

Day 28. The rats are very active. They play incessantly while awake. At this stage they are veritably "lieblichste Thierchen"—most fascinating little creatures. Their rapidity of movement is marvellous. The plays certainly cover a great many of the serious activities of adult life—including those of sex. They show no striking fear of me yet. Occasionally they run away after sniffing my hands, but this seems to be as much in sport as in fear.

Remarks on the Diary.

Prof. Mills, in his remarks upon the psychic development of his puppies, says: "The facts most striking in the first few days of life are the frequent desire to suck, the perfect ability to reach the teats of the dam just after birth, the misery evident under cold and hunger, and the fact that the greater part of existence is spent in the sleeping state." This statement is equally true of the young rats, if we add the facts of their rapid growth and change from the larval appearance, and of their vocal accomplishments. The desire for warmth and the desire for food seem to be their very first psychic experiences in life; the former preceding in time and being more imperative. A special significance of this fact will be noted later.

Sucking. Prof. Mills discusses fully the first character of this reaction, and concludes that it is not a "congenitally perfect or instinctive action" as the "sucking is not perfect at first," but "is improved with practice." My observations upon the young rats accord perfectly with the conclusions of Prof. Mills. The young rats find the teats largely by accident, aided by the mother who pushes and pulls them under her. I have not seen them attempt to suck other parts of the mother's body—the fur, *e. g.*,—as did Prof. Mills's puppies.[1] I am also of the opinion that smell plays no very important part in finding the teats at this early period. It is rather that they are attracted by the warmth of the mother's belly and find the teats accidentally.

Sensation. The infancy of the rat falls naturally into two distinct divisions: the period before the opening of the eyes and ears, and the period following this event. As noted in the diary the ears and eyes open almost simultaneously, from the

[1] Since writing this sentence I have seen a six-days-old rat sucking the mother's fur.

fifteenth to the seventeenth day. Before that time, taste, smell, the dermal and tactile groups, and the organic sensations are present.

Pain. The young rats experience pain from the very first—a slight pinch or prick or extreme heat bring out pain reactions. If one may judge, however, from the relative violence of reactions, sensitiveness to pain is much less acute at first than later.

Taste. The experiments seem to show that there is little or no discrimination of tastes at first. The reactions indicate that all tastes, except the taste of mother's milk, are disagreeable—some more than others, of course. It is possible that taste, properly speaking, is absent at first, and that the temperature, and the chemical and mechanical effects of the substances determine the reactions. The apparent disagreeableness of so many substances lends color to this supposition. Experience of sensations inherently pleasurable may be needed to neutralize the disagreeableness of the primitive shock.

Smell. Though taste and smell are intimately connected, it is comparatively easy to eliminate the taste element from the experiments on smell. It is certain that the young rats can sense odors immediately. The strong irritating fluids like HCl. produce, of course, a direct chemical effect upon the mucous membrane. This is positively painful, and the reaction may be regarded as the indication of a pure pain sensation, in spite of the genuine odor-element in this stimulus; but the reactions to other odors which are quite free from the irritating element prove beyond a doubt that the pure sense of smell is present at this early period. Whether there is discrimination of smells at first is doubtful. When three or four hours old the rats react from violet and cheese in about the same way, indicating that all odors are disagreeable at this time. This state continues for a day or two; then the rats begin to show discrimination. They turn away from some odors as if in disgust, approach others with something like satisfaction, and are apparently quite indifferent to others. This character of indifference extends to a larger field of odors as the rats get older. It is easy to distinguish between the act of sensing the odor and the affective reaction, though at first this is less easy. In the case of irritating fluids such discrimination is impossible, for the reaction to the stimulus is instaneous. With pure odors, however, even from the first there are movements,—adjusting the head and sniffing—indicative of sensing, which precede the movements expressive of pleasure or disgust. After the first few days the careful sensing of the odor before the affective reaction is clearly marked.

These facts are what might be expected from the anatomical character of the olfactory apparatus. The nose and olfactory

lobes are well developed at birth; but there is every reason to believe that the psychic results of this first functioning must be of a very general character. The machinery is all ready, but, like any other piece of new machinery, it needs use and oil in order to attain its maximum efficiency.

There seem to be considerable individual differences in regard to the smell sense at this early period. Some manifest indifference to most odors much earlier and more definitely than others.

As the sense of smell is the rat's psychical organ in food getting, we should expect to find the young rats developing the sense in the following order: (1) the initial stage of extreme sensitiveness, when all olfactory stimulations are displeasurable; (2) an intermediate stage, when all but positively detrimental stimulations are indifferent; (3) a period when there is developed discrimination of those odors associated with food from those not so associated. As a matter of fact, there is some such order as this. The stages are not marked, of course, by hard and fast lines; but the evolution from the first undifferentiated nose-consciousness to the point where food-stuffs and odors are definitely associated shows these phases. The process, however, is not entirely one of experimental association, through taste. The young rats show interest in the odors of cheese and milk, *e. g.*, long before they have tasted them.[1] On the other hand they are indifferent and even averse to the odors of many substances without ever tasting them. This selective faculty must be referred to the inherent character of the rat's nervous substance out of which is developed this psychic faculty by normal functioning.

One other question with regard to smell is suggested: have rats any pleasure in odors apart from their association with food? do odors arouse in them purely æsthetic feelings? There is no *a priori* objection to this supposition. It is well known that rats have an æsthetic sense with respect to hearing. I am convinced, too, that rats manifest curiosity apart from that curiosity which is directly associated with nutrition and reproduction. The analogies of these faculties are favorable to the view. Furthermore there is no valid objection from a strictly selectionist point of view, as the mere euphoria resulting from æsthetic olfactory sensations would certainly have a salutary influence in the vital struggle. Of positive evidence there is little. Darwin says that "rats are attracted by certain essential oils," but gives no hint as to the particular oils which have this power of attraction, so we do not know whether they

[1] The odor and taste of cold cow's milk are not identical with those of warm rat's milk.

are food-oils or otherwise. My own experiments have given no definite results either way.

DERMAL SENSATIONS. The young rats, from the first, respond to tactual stimuli. The temperature sense is well marked at birth. I am not so certain about the special tactile sensations.

Temperature. The temperature sense must not be confused with sensitiveness to atmospheric temperature. The psychosis in the latter case is a result of the condition of the whole organism, in which the vital processes are retarded and sensations of general organic discomfort are felt. The temperature sense is, of course, a dermal function merely, and is local in its scope. At birth, a hot substance, just below the burning point, produces a quick reaction; likewise any cold substance at about the freezing point.[1] Between these two extremes, I could get little or no reaction to temperature stimuli. It is impossible to test this sense after hirsutation, so I do not know whether there is an increase or decrease of acuteness. Sensitiveness to cold, however, decreases in ratio to hirsutation, though the white rats can never endure a low temperature.

Pressure, Tickling, and Mere Contact. These factors are too closely connected to permit separate consideration. At birth, light pressure, unaccompanied by motion, produces no reaction, especially if the pressure be exerted with a small body. Comparatively light mass-pressure elicits reaction. So far as I have been able to see, mere contact does not. Tickling, by drawing a hair over the body, produces little effect—often none at all if the pressure element is eliminated, but the same stimulus applied to the part of the nose where the feelers are, elicits a decided negative response. The acuteness of this group of sensations increases *pari passu* with the advance of hirsutation.

EQUILIBRIUM, SENSE OF SUPPORT, AND ORIENTATION. *Equilibrium.* The young rats from birth have a rudimentary sense of equilibrium. All their movements, inco-ordinated and ineffective as they are, show a preference for the belly position. If placed in any other position they strive to regain this one, and are not comfortable until they get it. (An exception to this is, of course, the tendency to lie upon the back when sucking, but that is a special office demanding special position.) The neuro-muscular mechanism, however, is so imperfectly developed at this period that effort is required constantly to maintain the normal position. By the end of the first week they are able to equilibrate pretty well, and before the end of the third week they maintain their balance under the most

[1] There is a possibility that what seems to be temperature sensation is pain sensation—but the temperatures tried are well within the normal limits. It cannot be mere contact, for similar contact at mean temperatures effected no reactions.

trying circumstances. I have made no tests to determine their susceptibility to dizziness, but have no reason to doubt that it is present from the start.

Orientation. This view of dizziness finds some support in the fact that they orient themselves with respect to up and down from the very first. I have not made any test to determine at what least angle they turn the head to the upward inclination, but certainly they do so at 30°. The adjustment is comparatively slow at first, but becomes instantaneous before many days.

I am of the opinion that there is a rudiment of lateral space orientation from the first. The new-born rats when placed on their backs struggle over on to their bellies. With the normally strong rats this effort is generally succeeded by an attempt to rise upon the legs. At the same time the head is stretched upward. Now this is the incipient stage of the characteristic orientation movement of the adult rat—rising upon hind legs with the tail as extra support, describing a circular movement with the head and sniffing all the time. As early as the fourth day these movements began to take on some definiteness, and by the seventh day they are associated with the selection of path and the avoidance of obstacles when the rats were crawling about. In view of the relatively unimportant part that sight plays in the life of the white rat—and probably of the rat in general—the relatively perfect orientatation in this way, long before the opening of the eyes and ears, is significant. As recorded in the diary a rat on the 11th day crawled directly across the cage to the mother—a distance of eight inches, and began to suck. This was six days before his eyes were open; and on the 15th day, two days before the eyes were open, one performed the difficult feat recorded on page 84. Now, as the same movements are used in orientation after the eyes and ears are opened, as before, one is led to conclude that the influence of the eye in the orienting process is very slight. The neural paths which are blazed out in this pre-visual state are the paths that continue to be used. If this is true it suggests two important principles in the study of comparative psychology—even when made experimentally, viz.: (1) the necessity of knowing your animal before you try to enter into experimental conversation with him; and (2) the immense differences in mental processes between not only the lower animals and man, but equally between different animals. The difference between the eye orientation of man and the nose orientation of the rat is not more specific than is that between lynx and rat.

Sense of Support. This phrase is suggested by Mills and commended by Morgan. Mills uses it to describe the sensation which land animals feel when they are deprived of a solid foun-

dation,—as, *e. g.*, when his puppy or kitten stops and shows uneasiness at the edge of a table. Mills thinks this sense is peculiar to land animals, and is congenital—a character which has been acquired since leaving aquatic life. The amphibious turtle, he remarks, will walk right off a table without any apparent sense of the difference of medium.[1] All young land animals, on the contrary, show hesitation when they approach a void; and even though they may be going too fast to stop, they yet make an effort to save themselves. Prof. Mills does not, of course, regard this as a simple sensation—but rather a feeling-complex of various dermal and organic elements. I do not see why it is not a lower stratum of acro-phobia (the fearof falling). My observation of the young rats is confirmatory of Prof. Mills's view. As early as the second day they show an uneasiness when on the edge of a void—sometimes drawing back, sometimes manifesting their dominant trait of curiosity by leaning over and sniffing. At the age of four or five days the presence of this sense is unmistakable, and is not due to experience, as I have found by trying rats that have had no such experience. I had noticed this phenomenon before reading Prof. Mills's remarks on this subject. His interpretation seems to be more satisfactory than anything I had thought of, though, as he himself points out, the case is not completely made out.

SIGHT AND HEARING. The eyes and ears begin to function the fifteenth to seventeenth day, different litters presenting this range of variation. The individuals of the same litter also present variations of several hours in some cases. (Every factor in this development-history seems to emphasize the frequency and range of congenital variation.) At birth there is no external ear—only a dermal fold—the incipient pinnæ. This begins to unfold from the front backwards about the second day and is at first semicircular in form. It attains its perfect form and a length of 6 or 7 mm. just before the meatus opens. The meatus indentation is seen first about the eighth day and assumes its perfect form at the same time as the pinnæ. The growth of the eye is analogous. All attempts to get reactions to sound or light before the opening of the ears and eyes failed. Even a powerful concussion near the ears was effectless. I regret to say that I did not try the effect of a powerful light close upon the unopened lids.

Sight. The question of what the young rats see is complicated by the question of what the adults see. The actions of the adult rats seem to indicate that they see motions rather than objects. I do not mean that they do not have images of objects, but rather that the images of motionless objects have

[1] But will a land tortoise?

little compelling power upon their attention. They follow a moving object with their eyes at a distance of several feet, but they always make their investigations of motionless objects with their noses. I made tests upon the young rats a few hours after the opening of their eyes. They showed some slight discomfort in a strong light, soon closed their lids and seemed drowsy. Throughout life, the white rats show a decided aversion to strong light. I infer from this fact, and the special signs of discomfort, that the first light stimulus is positively painful. The limit of vision is restricted at first. The eyes do not follow a moving object even at a distance of a few inches, and a winking reflex cannot be produced without almost touching the eye. The inference is pretty clear that the first eye-sensations are brightness-sensations and that the eye requires time to adjust itself to the new conditions; in a word, it is not functionally perfect, though it may be anatomically perfect.

Hearing. The ear is hyperæsthesic at first. All sounds—even very slight ones—elicit rather exaggerated responses. The bursting of a paper bag and the clapping of hands at a distance of ten feet, and the gentle rustling of paper at one foot, produced strongly marked reactions.

The rats discriminate between sounds, however, at this time. For instance, a gentle and prolonged whistle produced only a lifting of the head, as of attentive listening, whereas the hissing syllable "sh" caused terrified leaping. It is impossible to say whether there is complete discrimination between tones and noises, but all concussions call out the reflex jumping. I am of the opinion that intensity is more important than quality, at this time, in determining the reaction. Nevertheless, the observed facts in regard to the musical sense of rats and other varieties of the *muridæ*, prove that intensity is not the only factor determining their likes and dislikes. Not only have they a well developed æsthetic sense in respect to tone, but they also regard quality as well as intensity. It may be, therefore, that there is in this case, qualitative discrimination *ab initio*—or as soon as the "big buzzing confusion" has subsided a little.[1]

As smell is the rat's psychical organ of food-getting, so is

[1]This is a point which I have not studied carefully. Yet it is important, for it opens up the whole question of the æsthetic nature of the sub-human species. The data upon this subject are abundant but anecdotal. An ontogenetic experimental study of the musical sense of a few of our common animals could not fail to let in light upon the meaning of the æsthetic sense. The Darwinian interpretation seems inadequate. Sexual selection does not account for all the facts. Prof. Everett's suggestion as to the selective value of mirth, as a promotor of well-being, and hence an aid in the struggle for survival, may be applicable to this question as well.

hearing his psychical organ of defence. The initial hyperæsthesia of hearing means simply that the organism responds reflexly to these unwonted stimuli. It is instructive to note that at first these reflex recoils seem to produce little psychic effect (either perceptional or emotional). There is a motor explosion, and almost instantly the rat resumes his wonted attitude and occupation. Gradually, though rapidly, there is a change in all this, and the reflex recoils are followed by attitudes denoting fear or attention. The attentive attitude is very like that noted at first in response to whistling—the head lifted, etc. The fear-attitude is easily recognized. Later, other emotional states appear, concomitant with auditory stimulation. This indicates a rapid integration and functioning of the higher centers and the associative tracts, which at first are not functionally perfect. It is an analogous case with that of the sense of smell—with the difference of the post-natal anatomical perfecting of the auditory apparatus.

INSTINCTIVE ACTIVITIES. I shall confine my remarks upon this point, to a discussion of the question whether instinctive activities are congenitally perfect. This question, however, has been involved in so much confused and confusing dogmatism and speculation that I must pause to state clearly the limits of the question. Much of the dust stirred up by the various champions might have been avoided had these champions been clearer of their own meaning. The first and most necessary delimitation is to separate sharply the field of instinctive activities from that hypostatic entity known as instinct. This is seldom done; and, indeed, for some purposes it is unnecessary. Prof. Groos, *e. g.*, writing of Play, first elaborates a metaphysical notion of instinct, basing it upon a natural selection teleology; he then forces into an *omnium gatherum* all the voluntary movements of young animals and calls them plays; and then informs us that play is an instinct. Prof. James likewise includes under his category of instinct a quite heterogeneous group of psychic characters. For purposes of teleology and classification this procedure is very well. On the other hand, in a genetic study of instinctive activities the mind must be rigorously on guard against the intrusion of this metaphysical concept of instinct. The necessity for this will be apparent when we consider that two such remotely related phenomena as fear and the bridal flight of the bee are equally "illustrations of instinct." For the purposes of psychological inquiry, the only assumption we need to borrow from this hypostasis of instinct is that of its non-experiential character. All agree that an instinctive activity is one that is performed by an organism without previous experience. In psycho-physical terms, it is the impulse, the effort of an organism to act, with-

out previous experience, in a certain, definite, purposive way, under certain definite conditions. The range is therefore very great. But as "impulse and effort of an organism" are actualized only in motor terms, the instinctive activity is also conditioned by the neuro-muscular mechanism. A tentative definition might be then: an organic impulse, effecting through the neuro-muscular system, definite, purposive, motor ends. The question of the congenital perfectness of the instinctive activities is, therefore, a question of the functional perfectness of the neuro-muscular system at birth. If the neuro-muscular system is so co-ordinated and determined as to realize immediately and certainly the behest of the organic impulse, then the instinctive activity is congenitally perfect; otherwise, not. This means that in most cases instinctive activities are not congenitally perfect. Almost always the perfect instinctive activity is the congenital *set* of the organism *plus* the accuracy and definiteness of movement gained by exercise of the function.

In this view the young rat exhibits almost no congenitally perfect instinctive activities. Crying, which begins at birth, seems to be an indisputable case; also the sucking-reflex—not the complex of movements involved in sucking. All the other activities are inco-ordinated at first, whether manifested immediately after birth or only at a later time. I have set down the following as clear cases of instinctive activity under the provisional definition: Sucking, swallowing, chewing, crawling, clinging, climbing, digging, gnawing, washing, scratching (with hind foot), running, leaping, sex-movements (in play), and, possibly, the "picking" and licking noted in the diary. None of these are capable of immediate and perfect action at birth; some do not appear until several days or weeks after birth; yet all are clearly organic impulses in origin. Several may be called pure reflexes, but the evidence is not clear except in the case of sucking.[1] The face washing is an instructive example. The neuro-muscular mechanism necessary for this act is approximately perfect at birth, as proved by

[1] Prof. Romanes's attempt to prove that scratching with the hind feet is a pure reflex is inconclusive. His method was to amputate the hind feet of his subjects soon after birth, before the appearance of the activity in question. He found that the movements were performed in due time by the mutilated rats just as by the normals, though they were perfectly ineffective. The stump was merely waved in the air, never once touching the irritated spot. This demonstration is imperfect for he did not carry his experiments far enough to determine whether the rats would learn, in time, the uselessness of the movements and cease making them. Moreover, in order to make this demonstration analogous with that of the reflex frog, it would be necessary to find some way of *psychically* decapitating the rat, while leaving the spinal cord intact.

the vigorous brushing movements when a disagreeable olfactory stimulus is applied; but the first attempts at face washing I have noticed—and I have observed several litters with respect to this point—are not earlier than the tenth day. The other instinctive activities readily lend themselves to similar analysis.

Huddling. One of the most striking and characteristic activities of the young rats is that of huddling and piling up together. Of course this is a manifestation of the need of the organism for warmth. That indeed is their first need. They can endure a day of fasting much better than they can endure an hour of existence in a temperature of 40°. After birth they are immediately drawn under the mother's abdomen, where they are kept in a comparatively high temperature. Whenever the mother is removed or they are themselves taken from the nest, they immediately seek to pile up in a compact heap.

I am led to ask whether this is not one of the roots of the social instinct. I think it is by no means a new idea that the desire for warmth has been a factor in socialization; so there is no heterodoxy in the suggestion. This constant desire—imperative need—for warmth, drawing the animals into such intimate physical contact cannot fail to provide a basic social bond. As a matter of fact the adult animals retain the habit. Except in the very warmest weather a cage full of rats will always be found in a compact heap when at rest.

Play. The first distinct case of play I have noticed occurred on the eighteenth day, when I saw the young rats apparently hiding from each other in the excelsior of the nest; but before that time, there were anticipations of play activities in climbing, running, gnawing, etc. The development of the play activities was exceedingly rapid after this first case. On the nineteenth they were running constantly about the cage, climbing over each other and making occasional sallies at the loose excelsior. On the twentieth, they were chasing each other and I saw one tugging at another's tail. On the twenty-second, I saw them biting each other in play. By the twenty-fifth, their whole repertory of plays was complete: running, jumping, climbing, fierce sham fights (no anger ever), with biting, clawing and pommeling, running over the mother and biting her ears, digging in corners, gnawing at the cage, sex-motions, "picking," licking and fondling each other. Most of their playing is violent—frantic dashes up the sides of the cage, sudden leaps into the air, violent assaults upon each other. I have not made out whether all the play activities are definitely anticipatory—according to Groos's theory. My catalogue of plays is far from complete. It would be instructive to work from the other end, by making a complete catalogue of adult activities, and compare this with a

similar catalogue of infant play activities. It would be hard to get them all under Groos's blanket of anticipation, unless it be stretched rather beyond Groos's own usage. By making the law of selective utility of very broad generality, so as to include the general well-being induced by play as a factor of selective utility, one may make play fall under the domain of natural selection; but it is by no means evident that all the specific play activities of infancy are immediately and definitely propædeutic to specific necessary activities of maturity. It would be surprising, too, in this particular case if there were not found in the plays survivals of wild traits that are of no possible utility in their present mode of life. It is not improbable that some of the plays are mere kinetic equivalents for previous highly useful functions, the rudimentary organs of which persist in the infant organism. The subject of play is so new and so little exploited from the inductive side, that some important results ought to follow a careful study of the ontogenetic development of the play activities.

Affective States. From the very first, the young rats give evidence of experiencing feelings of general bodily discomfort, hunger, and pain. On the pleasurable side, they show signs of satisfaction when hunger and the desire for warmth are satisfied. Other emotional psychoses were manifested at later successive times.

Fear. The evidence of any fear psychosis, before the eyes and ears began to function, is not unequivocal. Before this, there were noted frantic efforts to recover disturbed equilibrium, violent reactions to sudden tactual stimulations and signs of disquietude when the rats came to the edge of the table, or when they were suspended from the finger. These reactions, however, are largely reflex, so it is impossible to say how much emotional significance they have. In view of the most satisfactory theories of emotion, the presumption is strong that there is an emotional accompaniment; at least, that there are organic disturbances, which are basic, physiologically, to emotional psychoses. On the other hand, it was quite clear that there was no instinctive fear of their natural enemies, mediated by the sense of smell, before the eyes and ears were open. The young rats showed not the slightest symptom of fear either of man or of cat, though I tested them almost daily by my own presence and by presenting my hand to their noses after having impregnated my hand with cat-odor by rubbing a cat. This fact is interesting in view of the opinion so generally held that animals with a keen sense of smell have a congenitally instinctive fear of their natural enemies. This is the more striking in the case of the rat, since his olfactory apparatus is extraordinarily well developed at birth. It must be assumed, how-

ever, that no instinctive fear exists. On the contrary, adult rats that have had no experience with cats show some uneasiness at the cat-odor. What the facts do seem to indicate is that the manifestation of instinctive fear waits upon the integration and functioning of the higher centers. An occurrence noted upon the same day the eyes and ears opened suggests to me that there may be an acceleration or consummation of this process simultaneously with the advent of these two senses. Before this time, handling of the rats had elicited no symptom of fear. On this occasion, however, one of the rats, when I put my hand into the nest and touched him from behind, ran hastily out of the nest. The significance of this action lies in its close simulation of the action of adult rats under like circumstances; they always show fear when touched suddenly from behind, but little or none if approached from before. If such an acceleration of development does take place at this time, it is not necessarily dependent upon the experience gained through these new sense avenues; the example cited could not be referred to any such experience, but must rather be referred to the functioning of the higher cerebral centers. It is patent, however, that after the functioning of the ears and eyes the fear field is immensely broadened, and becomes more specifically psychic.

Other specific emotions appear later. The pleasurableness of bodily comfort apparent in the first few days of life becomes positive joy when the neuro-muscular development permits of free and well co-ordinated movements—about the time of the opening of the eyes and ears. No case of anger was observed until very much later—not earlier than six or seven weeks. In all the tussling and fighting during play I have not seen a single rat lose his temper and "go at it in earnest."

Something like an altruistic sentiment is apparent in the mutual service which the young rats perform for each other by licking and "picking" vermin. I have recently seen adult rats tenderly lapping the eyes of sore-eyed mates. I think there is a considerable fund of altruism in the rat nature, in spite of the fact that they eat each other when very hungry—starving men do that!

Curiosity. As fear or timidity is the most striking of the emotional traits of the white rat, so is curiosity, of the *intellectual* traits. The premonitions of curiosity are to be seen in the restlessness of the young rats as soon as they are able to move freely. By the time they are three weeks old it is inordinate and overbalances fear. It is really curiosity, which is customarily spoken of as boldness by writers upon the natural history of the rat. Unless the rats happen to become special pets, their adult psychic life is a pretty even oscillation between these two states. Their curiosity is not entirely a matter of the stomach,

either. It may be supposed that a large part of their inquisitiveness is in the service of nutrition; but the biological necessity of safe surroundings is not less imperative. There is certainly a double root to this trait.

INTELLIGENCE. Upon this point there is little to be said. If we take intelligence in its objective, biological or teleological sense, *i. e.*, the power of the organism to adapt itself to new environment, the development of intelligence in these first four weeks is readily followed. At birth we see a larval organism, endowed with slight power of movement, insufficient to seeure food and warmth, or to avoid danger, insensitive to all external excitations except temperature and odors, endowed with no psychic life beyond desire, and pleasure and pain. Gradually we see this organism change from its larval appearance to a form indicative of energy and activity. As the neuro-muscular system develops, all those instinctive activities so necessary to life appear one by one; and with the anatomical and functional development of the several sense-organs, advances, *pari passu*, the sensational horizon. The repertory of motor and emotional instincts, functional and psychic traits is rapidly filled out; and at the end of the fourth week of life, we have the young rat in full possession of that power to learn by experience, to seek out advantageous things, and to avoid dangerous things, which we call intelligence. Little would be gained here by attempting to resolve any specific process of intelligence into its elements. The one case of imitation noted is an example: the young rat saw the mother doing a certain thing and did it himself. The most obvious explanation of this process is that the visual image of what the young rat saw touched off a motor impulse resulting in similar action; but the explanation is superficial—it fails to touch the most important part of the question—how the visual image connects with the motor image, or impulse. Similarly, the complex mental process involved in the action of the rat that pushed his fellow away from a dish of milk in order to have free access himself, could receive only a superficial explanation in associational terms.

Finally, the chief value of a study of this kind is not in the analysis of the intellectual processes, valuable as that may be, but rather in getting a picture of the psychic make-up of the animal—an insight into his character through an appreciation of his fundamental psychic traits, which persist with undiminished vigor through the vicissitudes of an environment different in all its factors from that of the free wild life in which his psychic nexus was woven in the loom of necessity.

ROMANES' IDEA OF MENTAL DEVELOPMENT.[1]

By MARION HAMILTON CARTER, B. S.

In a previous paper the present writer discussed Darwin's Idea of Mental Development.[2] This second article follows closely the lines there laid down.

§ 1. GENERAL PSYCHOLOGY.

Before beginning an inquiry into the views of Romanes upon Mental Development and its place in evolutional theory, it will not be without profit to take a brief survey of the system of psychology which he held, and which was an integral portion of his philosophical creed.

Unlike Darwin, Romanes has been looked upon, more or less, as a psychologist, and has left us several volumes upon psychological and philosophical questions. His speculations were not confined to natural philosophy, but embraced the ultimate realities and the nature of things in their last analysis. Romanes had begun to be interested in metaphysical subjects in his early manhood, and throughout his life and almost to the day of his death devoted much of his most earnest and critical thought to the problems of Man, of Right, of Duty, and of the Ultimate First Cause. It is beyond the pale of this study to give an account of the changes which took place in his philosophical and religious views. It is sufficient here to say that his was a mind ever reaching out toward explanations more ultimate than those that could be given by a study of natural phenomena alone, and that to him the investigation of nature by purely inductive methods could never be adequate or satisfying. Throughout his work, therefore, we find constant attempts to systematize, to bring all the data of science into harmony with a general plan or cosmological scheme.

Romanes has left us three volumes dealing with human and animal psychology. In so extensive a contribution one may reasonably expect from an author a definite and systematic statement of the fundamental data of his subject. For this, however, the reader will search these books in vain. In the work entitled *Mental Evolution in Animals* Romanes has given

[1] From the Psychological Seminary of Cornell University.
[2] *Amer. Jour. of Psychology*, Vol. IX, No. 4.

us chapters on the Criterion of Mind, the Physical Basis of Mind, Consciousness, Sensations, Pleasures and Pains, Memory and Association of Ideas, Percepts, Imagination and Instinct. In the *Mental Evolution in Man* he has continued the former book by chapters on Ideas, Logic of Recepts, Logic of Concepts, Self-consciousness, and Language.

It is possible that a clear and concise statement of the bare facts of human psychology appeared to him unnecessary in his treatment of the subject. It was his purpose to trace the development of the various mental processes from those occurring in the lowest organisms to those in the highest; and owing to this purpose he probably thought it not incumbent upon him to attempt any special work in systematic psychology as such. In addition to this, he had had little or no training in psychology, and his knowledge of it was derived from reading. I believe it is due to both these facts that his work in psychology has so little coherence. He relied upon the work of others to a surprising degree, and his treatment of human psychology is almost entirely made up of quotations, and contains little or nothing original excepting his discussion upon 'Recepts.' Romanes was the inventor of the term 'recept.' "In addition, then, to the terms Percept and Concept, I coin the word *Recept*. This is a term which seems exactly to meet the requirements of the case. For as perception literally means a *taking wholly*, and conception a *taking together*, reception means a *taking again*. Consequently, a recept is that which is taken again, or a re-cognition of things previously cognized. Now, it belongs to the essence of what I have defined as compound ideas (recepts), that they arise in the mind out of a repetition of more or less similar percepts."[1] 'Recepts' are general ideas which have not been given a name, and have not been consciously classified. The associations we have with them are of the passive kind, as the associations we have with the cognate words are of the active kind. In receiving such ideas the mind is passive, as in conceiving abstract ideas the mind is active. "Recepts, then, are *spontaneous associations, formed unintentionally* as what may be termed *unperceived abstractions*."[2]

In the *Mental Evolution in Man* Romanes devotes a lengthy chapter to the logic of recepts—a chapter much padded with quotations from Sully, Perez, J. S. Mill, Mansel, Huxley, Lazarus, Steinthal, F. Müller, Comte, Binet, G. H. Lewes, Darwin, Preyer, Leroy, Locke, Taine, besides some of his own previous works. What he wishes to set forth here is that along with "the logic of signs, there is a logic of images, and a logic

[1] *Mental Evolution in Man*, p. 36.
[2] *Ibid.*, p. 37.

of feelings."[1] The word 'recept' is taken to cover all those cases of the ideas on the borderland between percepts and concepts,—a disputed and often unrecognized region which Romanes set himself to investigate. "The question, then, which we have to consider is whether there is a difference of kind, or only a difference of degree, between a recept and a concept. This is really the question with which the whole of the present volume will be concerned."[2]

Romanes distinguished five kinds of ideas: the percept (a simple memory image), lower recepts, higher recepts, lower concepts, higher concepts, forming a perfect developing series, the one being closely united with the other by derivation, *i. e.*, by growth from the lower to the higher. In order to elaborate this theory more fully he had recourse to philology, and traced back the conceptual meanings of words to their 'receptual' origin. The following paragraph sums up his results clearly:

"Now I hold that this receptual nucleus of all our conceptual terms furnishes the strongest possible evidence, not only of the historical priority of the former, but also of what Professor Max Müller calls their 'dire necessity' to the growth of the latter. In other words, the facts appear conclusively to show that conceptual connotation (denomination) has always had—and can only have had—a receptual core (denotation) around which to develop. Psychological analysis has already shown us the psychological priority of the recept; and now philological research most strikingly corroborates this analysis by actually finding the recept in the body of every concept."

Thus Mental Evolution for him consisted not in Feeling, not in Sensitivity to Pleasure or Pain, not in Co-ordinated Movements, not in Will, but in the various types of Ideation from percept to 'higher concept,' in a progressive series,—from the mere recognition of sense impressions *as such*, to a classification of them, and a classification *known as such*. Between the percept and the concept the unnamed general idea formed for him the natural link, and in the field of unnamed general ideas Romanes thought he had discovered a *terra incognita* to be explored and exploited for the benefit of evolutional psychology. The data which he collected regarding human and animal psychology were examined and evaluated largely with reference to the light they threw upon his theory of recepts; and he made excursions into every region which seemed to promise facts bearing in any way upon it.

It will thus be seen that the term 'recept,' in giving him a clearly named, unbroken line of ideation from lower to higher, against which he could measure the ideation of any given individual or species of animals, was the keystone to the arch sup-

[1] *Ibid.*, p. 42.
[2] *Ibid.*, p. 45.

porting the larger part of his theory of mental development. The 'recept' was, in fact, the *sine qua non* of his evolutional psychology; he invented the term, defined its limits, and published a volume (*Mental Evolution in Man*), the bulk of which was devoted to the proof of the existence of recepts and the exposition of his theories concerning them. It was, therefore, a matter of considerable regret to him that the word was not recognized by psychologists and obtained no hold in scientific nomenclature.

The reason for this is obvious from the quotations given. A 'recept' signifies no new conscious element or connection of elements, no process which differs in kind from those already well known to psychology. The term stands for a logical, not a psychological fact, and it has, therefore, no place in the psychological analysis of mental processes. The moment this is appreciated the keystone drops from the arch, carrying with it most of the superstructure, and leaving in ruins the greater part of Romanes' work upon mental development. In his evolutional scheme he obtained intelligence from the upward push of reflex action through instinct, and his theory of the subsequent development of mind itself he builds from materials which for psychology, at least, do not exist. However mind may evolve, it certainly does not evolve by means of the number or complexity of the terms which can be logically analyzed as coming under the head of a single psychological process. Mental development, if it be a reality, is something other than a procession of logical categories.

Romanes' most popular work was his 'Animal Intelligence.' The collection of the material for this occupied him many years, was derived from a great variety of sources, and was critically sifted, all instances not well attested being excluded. To the facts given, however, he added his own interpretations,—interpretations frequently so anthropomorphic and crude as to have scarcely a shadow of a claim to the consideration of the student of psychology. Some of these are not of his actual authorship, but since he quotes them without comment we are justified in laying the responsibility for them upon him.

From the Rev. W. Farren White he gives the following: "I have noticed in one of my formicaria a subterranean cemetery, where I have seen some ants burying their dead by placing earth above them. *One ant was evidently much affected*, and tried to exhume the bodies, but the united exertions of the yellow sextons were more than sufficient to neutralize the effort of the *disconsolate mourner*."[1] [Italics mine.]

He quotes from Dr. Kemp an account of a strange queen bee attempting to enter a hive; the workers "surround her and hold her until she

[1] *Animal Intelligence*, p. 92.

starves to death; *but such is their respect for royalty* that they never attempt to sting her."[1] [Italics mine.]

It is needless to multiply instances,[2] as I must give in full the tale of the Cat and the Thumb-latch.

"My own coachman once had a cat which, certainly without tuition, learnt thus to open a door which led into the stables from a yard into which looked some of the windows of the house. Standing at these windows when the cat did not see me, I have many times witnessed her *modus operandi*. Walking up to the door with a most matter-of-course kind of air, she used to spring at the bottom of this half-loop handle just below the thumb-latch. Holding on to the bottom of this half-loop with one fore-paw, she then raised the other to the thumb-piece, and while depressing the latter, finally with her hind legs scratched and pushed the doorposts so as to open the door. Precisely similar movements are described by my correspondents as having been witnessed by them.

"Of course, in all such cases the cats must have previously observed that the doors are opened by persons placing their hands upon the handles, and, having observed this, the animals forthwith act by what may be strictly termed rational imitation. But it should be observed that the process, as a whole, is something more than imitative. For not only would observation alone be scarcely enough (within any limits of thoughtful reflection that it would be reasonable to ascribe to an animal) to enable a cat upon the ground to distinguish that the essential part of the process as performed by the human hand consists, not in grasping the handle, but in depressing the latch; but the cat certainly never saw any one, after having depressed the latch, pushing the doorposts with his legs; and that this pushing action is due to an originally deliberate intention of opening the door, and not to having accidentally found this action to assist the process, is shown by one of the cases communicated to me (by Mr. Henry A. Gaphaus); for in this case, my correspondent says, 'the door was not a loose-fitting one by any means, and I was surprised that by the force of one hind leg she should have been able to push it open after unlatching it.' Hence we can only conclude that the cats in such cases have a very definite idea as to the mechanical properties of a door; they know that to make it open, even when unlatched, it requires to be *pushed*—a very different thing from trying to imitate any particular action which they may see to be performed for the same purpose by man. The whole psychological process, therefore, implied by the fact of a cat opening a door in this way is really most complex. First the animal must have observed that the door is opened by the hand grasping the handle and moving the latch. Next she must reason by 'the logic of feelings'—if a hand can do it, why not a paw? Then, strongly moved by this idea, she makes the first trial. The steps which follow have not been observed, so we cannot certainly say whether she learns by a succession of trials that depression of the thumb-piece constitutes the essential part of the process, or, perhaps more probably, that her initial observations supplied her with the idea of clicking the thumb-

[1] *Ibid.*, p. 164.

[2] Parallel cases will be found on the following pages of *Animal Intelligence:* pp. 76, 88, 90, 92, 94, 157, 158, 160, 162, 166, 169, 183, 187, 196, 211, 227, 228.

In *Mental Evolution in Animals*, p. 156, the story of the Dog and the Bone rivals, in interpretation, that of the Cat and the Thumb-latch.

piece. But, however this may be, it is certain that the pushing with the hind feet after depressing the latch must be due to adaptive reasoning unassisted by observation; and only by the concerted action of all her limbs in the performance of a highly complex and most unnatural movement is her final purpose attained."[1]

The cat's reasoning processes by 'the logic of feelings' call for no comment from me, but of the last sentence I may say that it seems typical of all of Romanes' psychological work. "It is certain," he says, "that the pushing with the hind feet after depressing the latch must be due to *adapted reasoning unassisted by observation.*" [Italics mine.] Cat pushes door with hind feet; cat makes necesary adjustments by 'adaptive reasoning.' Now the pushing may have been 'unassisted by observation,' but it does not follow that it was a result of 'adaptive reasoning,'—whatever that may mean. This is a fair sample of the kind of explanation that scientific men with little knowledge of psychology turn out as contributions to psychology.

Now to provide the very first step of proof for 'adaptive reasoning' in the cat-case we ought to have had the cat's *first spring* at the door-latch described to the minutest details. Could we see the cat on the ground laying her plans, and then forthwith carrying them out promptly and perfectly, we might be able to attribute the results to 'adaptive reasoning;' but since a minute account of the first spring is not forthcoming, the only probable explanation is that when the cat hung upon the thumb-latch she tried, after the manner of cats, to obtain additional support for her weight by driving the claws of her hind feet into the wood work. Being near the jamb, one of her feet rested easily upon it; an accidental and harder push with that foot caused the door to give slightly. The opening of the door being her object, her attention is sooner or later caught by the connection between her own push and the movement of the door. The action once accomplished is again and again repeated until perfected.

I have seen an analogous case with a kitten. She has tried to leap upon a window sill from the floor. Three long curtains hang from the top of the window, a lace net, which covers the window, and two velvet curtains which hang one at each side. After a great many ineffectual attempts to penetrate the lace at the middle of the window, the kitten on one occasion endeavored to climb up the curtains where the velvet overlapped the lace. In pulling first on one and then on the other, while mounting step by step, she separated the curtains, and thus easily reached the sill. This happy accident, repeated many times, has led to her complete mastery of the adjustments of

[1] *Animal Intelligence*, pp. 420-22.

actions necessary to reach the sill. Having watched her first attempts and her numberless failures, it seems to me it would take a large fund of credulity, imagination and ignorance combined to assign to the finished product even a modicum of 'adaptive reasoning.'

The cat and the thumb-latch story shows a complete absence of experience in tracing the genesis of a process, and is sufficient to discredit a man's whole work in comparative psychology. Common observation of the early actions of an animal ought to be enough to prevent the wholesale importation of reasoning processes into the explanation of the later and perfected actions, just because those actions appear as reasonable. In everyday language, all action performed with an end in view is considered reasonable, provided that the end makes for the advantage of the individual, but it does not, therefore, follow that any reasoning process whatever is called into play.

Before closing this survey of the contributions Romanes made to general psychology I must say a few words regarding his writings as a whole. Unfortunately much of the usefulness of his work is impaired by his literary style. In his large books on Mental Evolution there are literally dozens of pages, supposed to stand for general surveys or general summaries, which are merely collections of remarks to the reader about what he has seen, will see, or ought to see, if he looks,—remarks which add nothing to the author's statements or arguments. Besides these, there are hundreds of lines telling us what the author is about to do next.[1] In the chapter on Comparative Philology alone these remarks amount to nearly a printed page.

Good as some of his work really was, the verbosity of his style, the constant and lengthy quotations, the repetition of earlier and the anticipation of later statements and arguments, make his books difficult and unprofitable reading for the student of biology, psychology or philosophy.

That he carried weight in his day and generation is a fact. Why he carried the weight he did is to be explained more by the outward conditions of his life than by the value of his work from either a literary or a scientific point of view. He was the friend of Darwin,—to a certain extent, his literary executor, in that he received all of Darwin's notes on psychology, and published the essay on Instinct as an Appendix to a book of his own; his work in physiology had received favorable notice from most of the leading physiologists of his day; being the man that he was as a personality, as a friend,—and, above all, writing at a time when any one giving a fairly lucid exposition of the principles of evolution received attention, and was

[1] See, for instance, *Mental Evolution in Man*, pp. 244-45.

regarded as an authority,—with all these facts conspiring in his favor, it is hardly to be wondered at that Romanes obtained for himself a hearing and carried weight with the general public out of all proportion to the value of his work.

One cannot read his psychological books and deny that he was painstaking in the collection of material and careful in its elaboration; or, on the other hand, deny that his ill-worked-out theories are based upon voluminous quotations from writers, some of whom were even then antiquated, and many more, specialists in subjects other than those in whose support they are cited. One lays them down with the feeling that they form but an amorphous, inorganic whole.

§ 2. Mind in the Causal Series.

Does mind come into the causal series of organic evolution at large? Is it actively concerned in progress, *i. e.*, has it a "survival value?"

Regarding mind in the causal series at large, Romanes is either much less certain, or much more guarded in his views than Darwin, and he has left us both meager and somewhat contradictory statements concerning it. He says: "We have now seen that instincts may have what I term a blended origin —or, in other words, that intelligent adjustment by going hand in hand with natural selection, must greatly assist the latter principle in the work of forming instincts, inasmuch as it supplies to natural selection variations which are not merely fortuitous, but from the first adaptive. I shall next show what I conceive to be the chief modes in which intelligence thus operates, or co-operates with selection, in the formation of instincts."[1] This would seem to indicate that mind was 'actively concerned in progress.' And in his Rede lecture 'Mind and Motion'[2] he has the following:

> "To adduce only one other consideration. Apart from all that I have said, is it not in itself a strikingly suggestive fact that consciousness only, yet always, appears upon the scene when the adjustive actions of any animal body rise above the certain level of intricacy to which I have alluded? Surely this large and general fact points with irresistible force to the conclusion, that in the performance of these more complex adjustments, consciousness—or the power of feeling and the power of willing—is of some *use*. Assuredly on the principles of evolution, which materialists at all events cannot afford to disregard, it would be a wholly anomalous fact that so wide and important a class of faculties as those of the mind should have become developed in constantly ascending degrees throughout the animal kingdom, if they were entirely without use to animals. And, be it observed, this consideration holds good whatever views we may happen to enter-

[1] *Mental Evolution in Animals*, p. 219.
[2] *Mind and Motion*, pp. 24-5.

tain upon the special theory of natural selection. For the consideration stands upon the general fact that all the organs and functions of animals are of use to animals: we never meet, on any large or general scale, with organs and functions which are wholly adventitious. Is it to be supposed that this general principle fails just where its presence is most required, and that the highest functions of the highest organs of the highest animals stand out of analogy with all other functions in being themselves functionless? To this question, I, for one, can only answer, and answer unequivocally, no. As a rational being who waits to take a wider view of the facts than that which is open to the one line of research pursued by the physiologist, I am forced to conclude that not without a reason does the mind exist in the frame of things: and that apart from the activity of mind, whereby motion is related to that which is not motion, this planet could never have held the wonderful being, who in multiplying has replenished the earth and subdued it—holding dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth."

He speaks of the art of writing as of "inestimable advantage" to civilized man over savage man in "the consequent transmission of effects of culture from generation to generation."

"Quite apart from any question as to the hereditary transmission of acquired characters, we have in this *intellectual* transmission of acquired *experience* a means of accumulative cultivation quite beyond our powers to estimate. For, unlike all other cases where we recognize the great influence of individual use or practice in augmenting congenital 'faculties' (such as in the athlete, pianist, etc.), in this case the effects of special cultivation do not end with the individual life, but are carried on and on through successive generations *ad infinitum*. Hence, a civilized man inherits mentally, if not physically, the effects of culture for ages past, and this in whatever direction he may choose to profit therefrom. Moreover—and I deem this an immensely important addition—in this unique department of purely intellectual transmission, a kind of non-physical natural selection is perpetually engaged in producing the best results. For here a struggle for existence is constantly taking place among 'ideas,' 'methods,' and so forth, in what may be termed a psychological environment. The less fit are superseded by the more fit, and this not only in the mind of the individual, but, through language and literature, still more in the mind of the race."[1]

It would seem from this that he looked upon intelligence as having a "survival value" in the organic series.

In his philosophical views as to the ultimate relations of brain and mind, of which I shall speak later, Romanes was a monist, and this position would be irreconcilable with any concept of mind as *dipping into* a progressing series at various points, and acting thereby as a causal agent.

The quotations given, indicative of a causal relation between mind and an organic series, contain nearly all that Romanes said upon the subject. In view of the meagerness of his remarks, and of what must be termed their distinctly contra-

[1] *Darwin and After Darwin*, p. 33.

dictory character when taken in the light of his monistic theory of the relation of mind and body, we can only safely say that mind played *some* part in Romanes' scheme of organic evolution, but just what he does not tell us.

§ 3. Definition of Mind.

Unlike Darwin, Romanes was precise in his definition of mind. In the Introduction to *Animal Intelligence* he gives us an explicit statement of what he intended the term to cover, a statement which he substantially repeated in *Mental Evolution in Animals*. Romanes drew the line of mind much more closely than did Darwin. His purpose, however, differed widely from Darwin's, and it was to the advantage of his theory of mental evolution to limit, rather than to extend the meaning of his term. The purpose which underlay his entire work in evolutional psychology was the proof of the "probable genesis of mind from non-mental antecedents."[1] By placing the most rigorous strictures upon mental elements, the non-mental elements were brought within easy reach of the theory, being nothing more nor less than instinctive and reflex actions,—two sorts of action which Darwin had included in a general lump sum of mentality.

The criteria of mind for Romanes were threefold: first, the manifestation must be present in a living organism; 2nd, the manifestation must exhibit consciousness and choice; and, lastly, the organism must show itself "able to learn by its own individual experience." Mental evolution he expressed in a comparatively simple series: Reflex Action, Instinct, Intelligence.

"*Reflex* action is non-mental neuro-muscular adjustment, due to the inherited mechanism of the nervous system, which is formed to respond to particular and often recurring stimuli by giving rise to particular movements of an adaptive, though not of an intentional kind.

"*Instinct* is reflex action into which there is imported the element of consciousness. The term is, therefore, a generic one, comprising all those faculties of mind which are concerned in conscious and adaptive action, antecedent to individual experience, without necessary knowledge of the relation between means employed and ends attained, but similarly performed under similar and frequently recurring circumstances by all the individuals of the same species.

"*Reason* or intelligence is the faculty which is concerned in the intentional adaptation of means to ends. It therefore implies the conscious knowledge of the relation between means employed and ends attained, and may be exercised in adaptation to circumstances

[1] *Animal Intelligence*, p. 3. On p. 5 'evolution' is substituted for 'genesis.'

novel alike to the experience of the individual and to that of the species."[1]

To the above quotation may be added these further statements taken from the *Mental Evolution in Animals.*

"Whenever this stage is reached, and a nerve center begins to become conscious of its own working, we pass, according to my classification, from the domain of reflex action into that of instinct—instinct being in my terminology reflex action into which there is imported the element of consciousness."[2]

"Now, in so far as instinct requires to be mixed with intelligence in order to be effective, it is as an instinct imperfect; it is as an instinct in course of formation, or at any rate not perfectly adapted to the possible circumstances of life."[3]

"While the stimulus to a reflex action is, at most, a sensation, the stimulus to an instinctive action can only be a perception."[4]

"The advent and development of consciousness, although progressively converting reflex action into instinctive, and instinctive into rational, does this exclusively in the sphere of subjectivity;"[5] and "instinct passes into reason by imperceptible degrees."[6]

In view of the facts, however, Romanes was not able to maintain the continually upward trend of instinct, but was obliged to admit that instincts were mixed in their origin, some being "pure," and some "lapsed intelligence;" the latter he called secondary instincts.

" . . . . Adjustments originally intelligent may, by frequent repetition, become automatic, both in the individual and in the race; as instances of such 'lapsed intelligence' in the individual I have given the highly co-ordinated and laboriously acquired actions of walking, speaking, and others."[7]

Almost the whole of Vol. II of *Darwin and After Darwin* is devoted to the question of character as hereditary and acquired, and hence to those of the development and meaning of reflex action, instinct and intelligence, and of the inheritance of structural useful or non-useful peculiarities. His earlier views are here treated somewhat more from a biological standpoint; nevertheless there is substantial agreement with those of his psychological work.

To sum up, then, Romanes meant by the term 'mind' Intelligence in the common acceptation of the word, and did not include in it either instinct or reflex actions.

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[1] *Ibid.*, p. 7.
[2] *Mental Evolution in Animals*, p. 319.
[3] *Ibid.*, p. 176.
[4] *Ibid.*, p. 260.
[5] *Animal Intelligence*, p. 12.
[6] *Ibid.*, p. 16.
[7] *Mental Evolution in Animals*, p. 200.

§ 4. Relation of Mind and Body.

If Romanes was not clear upon the place of mind in an evolving series, he had, on the other hand, worked out clearly and somewhat fully the relation obtaining between mind and body. For him, as for Darwin, there was a distinct parallelism between "structural affinity and mental development."

"There is, indeed, a general and, philosophically considered, most important parallelism running through the whole animal kingdom between structural affinity and mental development; but this parallelism is exceedingly rough, and to be traced only in broad outlines, so that although it is convenient for the purpose of definite arrangement to take the animal kingdom in the order presented by zoölogical classification, it would be absurd to restrict an inquiry into Animal Psychology by any considerations of the apparently disproportionate length and minute subdivision with which it is necessary to treat some of the groups. Anatomically, an ant or a bee does not require more consideration than a beetle or a fly; but psychologically there is need for as great a difference of treatment as there is in the not very dissimilar case of a monkey and a man."[1]

This rough parallelism, however, betokened a deeper, underlying unity in the relation of mind and body,—a relation, not between mind and body in gross, but between consciousness and nerve processes. "We have already taken it for granted that Mind has a physical basis in the functions of the nervous system, or that every mental process has a corresponding equivalent in some neural process. I shall next endeavor to show how precise this equivalency is."[2]

And again. "It is enough if we are agreed that every psychical change of which we have any experience is invariably associated with a definite physical change, whatever we may suppose to be the nature and significance of this association."[3]

He also pointed out the parallelism between pathological mental and physical states. "But for the sake of systematic completeness I shall conclude this exposition by briefly pointing out that all those pathological derangements which occur in the nervous centers that preside over muscular activities, have their parallels in similar derangements which occur in the nervous centers that are concerned in mental activities."[4]

In the *Mental Evolution in Animals* Romanes devotes several chapters to the nervous system as the physical basis of mind; not only is brain the seat of mind, but its microscopic elements are the substrate of mental processes, and in these elements he finds the objective side of psychical processes from simple sensation to complex association.

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[1] *Animal Intelligence*, pp. 9 and 10.
[2] *Mental Evolution in Animals*, p. 34.
[3] *Ibid.*, p. 47.
[4] *Ibid.*, p. 44.

The following quotations will make this clear:

"This, of course, is just as it ought to be, if the brain, which the skull has to accommodate, has been gradually evolved into larger and larger proportions in respect of its cerebral hemispheres, or the upper masses of it *which constitute the seat of intelligence.*"[1] [Italics mine.]

"Within experience mind is invariably associated with highly differentiated collocations of matter and distributions of force, and many facts go to prove, and none to negative, the conclusion that the grade of intelligence invariably depends upon, or at least is associated with, a corresponding grade of cerebral development."[2]

"That the grey matter of the cerebral hemispheres is the exclusive seat of mind is proved in two ways. In the first place, if we look to the animal kingdom as a whole, we find that, speaking generally, the intelligence of species varies with the mass of this grey matter. Or, in other words, we find that the process of mental evolution, on its physical side, has consisted in the progressive development of this grey matter superimposed upon the pre-existing nervous machinery, until it has attained its latest and maximum growth in man.

"In the second place, we find that when the grey matter is experimentally removed from the brain of animals, the animals continue to live; but are completely deprived of intelligence. All the lower nerve centers continue to perform their mechanical adjustments in response to suitable stimulation; but they are no longer under the government of the mind."[3]

"There can be no doubt that in the complex structure of the cerebral hemispheres one nervous arc (*i. e.*, fibres, cells and fibres) is connected with another nervous arc, and this with another almost *ad infinitum;* and there can be equally little doubt that processes of thought are accompanied by nervous discharges taking place, now in this arc, and now in that one, according as the group of nerve-cells in each arc is excited to discharge its influence by receiving a discharge from some of the other nerve-arcs with which it is united. . . . . We thus see that the most fundamental of psychological principles—the association of ideas—is merely an obverse expression of the most fundamental of neurological principles—reflex action."[4]

The problem which confronted him consisted in showing that if body could be looked upon in any way as the physical substrate of mind, a relation must exist between them such that phenomena occurring in the one must subtend corresponding phenomena occurring in the other. Without such correspondence of phenomena in the two, a relation between them, if present, would be beyond the bounds of human demonstration. Unable to find an exact parallelism between gross anatomy and mind, Romanes endeavored, by reducing his terms to microscopic proportions, likewise to reduce the difficulties of his problem.

But not even in the cell did he discover a final and satisfactory solution, and he was obliged to appeal to plain matter and force in the last analysis.

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[1] *Darwin and After Darwin*, Vol. I, p. 196.
[2] *Theism*, p. 103.
[3] *Mind and Motion*, pp. 5-6.
[4] *Mental Evolution in Animals*, pp. 37-8.

"What we know as mind is dependent (whether by way of causality or not is immaterial) on highly complex forms of *what we know* as Matter, in association with peculiar distributions of *what we know* as Force."[1]

In a work entitled *Mind and Motion and Monism*, most of the chapters of which have appeared as magazine articles, he takes up the metaphysical side of this relation of mind and body. After discussing causality in general, he points out that "the only resemblance between this supposed case of causation (from neurosis to psychosis) consists in the invariability of the correlation between cerebral process and mental processes; in all other points the analogy fails."[2]

"I could certainly prove that whatever the connexion between body and mind may be, we have the best possible reasons for concluding that it is not a causal connexion."[3]

The following paragraph from *Theism*, written some twenty years earlier, takes up the same position as is held in the *Mind and Motion and Monism*:

"So long as Matter and Mind, x and y, are held to be antithetically opposed in substance, so long must materialism suppose that a connection of causality subsists between the two, such that the former substance is *produced* in some unaccountable way by the latter. But when Mind and Matter, x and y, are supposed to be identical in substance, the need for any additional supposition as to a causal connection is excluded. But unless we hold what seems to me an uncalled for opinion, that the essential feature of Materialism consists in a postulation of a causal connection between x and y, it would appear that the only effect of supposing x and y to be really but one substance, z, must be that of *strengthening* the essential doctrine of Materialism—the doctrine, namely, that conscious intellectual existence is *necessarily* associated with that form of existence which we know phenomenally as Matter and Motion. If it is true that a "moving molecule of inorganic matter does not possess mind or consciousness, but it possesses a small piece of Mind-stuff," then assuredly the central position of Materialism is shown to be impregnable. For while it remains as true as ever that mind and consciousness can only emerge when what we know phenomenally as "Matter takes the complex form of living brain," we have abolished the necessity for assuming even a causal connection between the substance of what we know phenomenally as matter and the substance of what we know phenomenally as Mind: we have found that, in the last resort, the phenomenal connection between what we know as Matter and what we know as Mind is actually even more intimate than a connection of causality; we have found that it is a substantial identity."[4]

Since it is not within the scope of this study to give the arguments by which our author reached his conclusions, but merely to state the views he held upon certain definite questions, I will

[1] *Theism*, p. 188.
[2] *Mind and Motion and Monism*, p. 62.
[3] *Ibid.*, p. 20.
[4] *Theism*, pp. 186-7.

sum up his various writings upon the ultimate nature of the relation of mind and body by saying that Romanes held it to be much deeper than a causal connection. The known data were to him inexplicable upon the theory of the interaction of two independent realities, and it was in the theory of monism that he sought, and believed that he had found, the solution of his problem. "This theory is, as we have already seen, that *mental phenomena* and *physical phenomena*, although apparently *diverse, are really identical.*"

"If we thus unite in a higher synthesis the elements both of spiritualism and of materialism, we obtain a product which satisfies every fact of feeling on the one hand, and of observation on the other. We have only to suppose that the antithesis between mind and motion—subject and object—is itself phenomenal or apparent; not absolute or real. We have only to suppose that the seeming duality is relative to our modes of apprehension; and, therefore, that any change taking place in the mind, and any corresponding change taking place in the brain, are really not two changes, but one change."[1]

§ 5. What Evolves in Mental Evolution?

What evolves in 'mental evolution,'—mind, body, or both mind and body? If mind only, how can it influence organic evolution? If body only, how does its evolution carry with it the evolution of mind? If both, what is the course of 'mental evolution?'

From the data already given regarding the relation of mind and body, the question as to what evolves in mental evolution might almost be expected to answer itself. Not so. No problem which Romanes wrote upon was so clumsily treated, or left more at loose ends than this. With the statement of the absolute monism of mind and body, the presence of mind in each and every bodily, or at least neural process would seem a necessary deduction. For him it was otherwise.

Romanes had taken upon himself the task of elucidating a theory of mental development in which the genesis of mind is to be traced from non-mental elements, *i. e.*, from instinct and reflex action and, indeed, from physiology itself. This evolutional theory attempted to do for mind what Darwin had done for species, to show a graded series from lower to higher, and a continuity in that series by means of natural inheritance.

"My position is that Mind is everywhere continuous, and if for purposes of analysis or classification we require to draw lines of demarcation between the lower and the higher faculties thereof, I contend that we should only do so as an evolutionist classifies his animal or vegetable species: higher or lower do not betoken differences of *origin*, but differences of *development*."[2]

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[1] *Mind and Motion and Monism*, pp. 83-84.
[2] *Mental Evolution in Man*, p. 234.

"I hold that if the doctrine of Organic Evolution is accepted, it carries with it, as a necessary corollary, the doctrine of Mental Evolution, at all events as far as the brute creation is concerned. For throughout the brute creation, from wholly unintelligent animals to the most highly intelligent, we can trace one continuous gradation; so that if we already believe that all specific forms of animal life have had a derivative origin, we cannot refuse to believe that all the mental faculties which these various forms present must likewise have had a derivative origin. And, as a matter of fact, we do not find any one so unreasonable as to maintain, or even to suggest, that if the evidence of Organic Evolution is accepted, the evidence of Mental Evolution, within the limits which I have named, can consistently be rejected. The one body of evidence therefore serves as a pedestal to the other, such that in the absence of the former the latter would have no *locus standi* (for no one could well dream of Mental Evolution were it not for the evidence of Organic Evolution, or for the transmutation of species); while the presence of the former irresistibly suggests the necessity of the latter, as the logical structure for the support of which the pedestal is what it is."[1]

Such are the general outlines of his fundamental postulates of the evolution of mind.

The *modus operandi* is less simple than it seems. Having started to evolve mind from non-mental elements, Romanes has recourse to physiology, and there finds the root principles of intelligence.

"Looking, then, at the phenomena of Mind as invariably presenting a physical, or, as we may indifferently call it, a physiological side, I shall endeavor to point out what I conceive to be the most ultimate principle of physiology which analysis shows to be common to them all. On the mental side, as we have already seen, we have no difficulty in distinguishing this ultimate principle, or common characteristic, as that which we designate by the term Choice. Now if the power of choice is the distinctive peculiarity of a mental being, and if, as we have taken for granted, every change of Mind is associated with some change of Body, it follows that this distinctive peculiarity ought to admit of being translated into some physiological equivalent. Further, if there is any such physiological equivalent to be found, we should expect to find it much lower down in the scale of physiological development than in the functions of the human brain. For not only do the lower animals manifest, in a long descending scale, powers of choice which gradually fade away into greater and greater simplicity; but we should be led *a priori* to expect, if there is a physiological principle which constitutes the objective basis of the psychological principle, that the former should manifest itself more early in the course of evolution than the latter. For, whatever views we may entertain concerning the relation of Body and Mind, there can be no question, on the basis of the evolution theory which I assume, that, as a matter of historical sequence, the principles of physiology were prior to those of psychology; and therefore, if in accordance with our original agreement we allow that the latter have a physical basis in the former, it follows that the principles of physiology, which now constitute the objective basis of choice, whatever they may be, probably came into operation long before they were sufficiently evolved thus to constitute the foundation of psychology."[2]

[1] *Mental Evolution in Animals*, p. 8. [2] *Ibid.*, pp. 47-8.

It is to excitability that he looks for a solution of the problem. "Thus, co-extensive with the phenomena of excitability, that is to say, with the phenomena of life, we find this function of selective discrimination; and, as I have said, it is this function that I regard as the root-principle of Mind. . . . . The distinguishing property of mind, on its physiological side, consists in this power of discriminating between different kinds of stimuli, irrespective of their degrees of mechanical intensity."[1]

To the question, then, 'what evolves in mental evolution, mind or body?' Romanes answers "Both evolve;" yet by the above showing there is not a mutual conditioning of each by the other—as Darwin held regarding them—but a very definite and precise conditioning of the mind by the body, never the reverse.

From mere excitability and discrimination of single cells, we pass upward to "ganglia which have fully *learned* their work" (*M. E. in A.*, p. 36), or "a ganglion (which) may *forget* its activity" (*Ibid.*, p. 75), until at last we find that "Reasoning consists in a selective discrimination among all those exceedingly delicate stimuli which, on their subjective side, we know as arguments. Similarly regarded, Judgment is likewise nothing more than the final result of the incidence of a vast number of very delicate stimuli; and this final result, like all the intermediate steps of the reasoning which led to it, is nothing more than the exercise of a power to discriminate between the stimulus which on its subjective side we recognize as the right, and that which we similarly recognize as the wrong. Lastly, Volition, subjectively considered, is the faculty of consciously selecting motives; and motives, objectively considered, are nothing more than immensely complex and inconceivably refined stimuli to nervous action."[2]

In the course of Mental Evolution, then, physiological function and morphological structure precede the advent of mental activity in point of time, *and the evolution of these carries with them the evolution of Intelligence* by means of the increasing differentiation and complexity of the neural elements which serve as the Physical Basis of Mind.

Summary.

We have seen (1) that Romanes held but vaguely that mind is causally related to organic evolution; (2) that the relation of mind to body was one of complete monism; (3) that by *mind* he meant only such manifestations of the living organism as

[1] *Ibid.*, pp. 51 and 53.
[2] *Mental Evolution in Animals*, p. 53.

gave evidence of purpose and choice; and (4) that Mental Development "consists essentially in a progressive co-ordination of progressively developing faculties" (*M. E. in A.*, p. 40), preceded by a morphological and physiological evolution of its physical substrate, the body.

His postulation of the development of Mind from non-mental elements, together with the priority of physiology over mind in point of time, give him a philosophical position among the Materialistic Monists.[1]

[1] It may throw a side light upon Romanes' views to glance at the literature to which he referred in his psychological works. Some fifty titles will be found in the books on Mental Evolution, the most important authors being Bain, Bastian, Binet, Carpenter, Darwin, Fiske, Houzeau, Huxley, Lazarus, Lewes, Maudsley, Jas. Mill, J. S. Mill, Max Müller, Perez, Preyer, Ribot, Spencer, Sully, Taine and Wundt. If we may judge from the quantity and general character of his quotations, Romanes seems to have derived his psychology mainly from the following five volumes: G. H. Lewes, *Problems of Life and Mind;* Max Müller, *Science of Thought;* Herbert Spencer, *Principles of Psychology;* H. Taine, *On Intelligence;* W. Wundt, *Vorlesungen über die Menschen u. Thierseele.*

It is hard to understand how a careful student could print work upon psychology, and yet omit to mention a score, at least, of the most important books on the subject. The year of the publication of *Mental Evolution in Man* (1889), Fechner's *Elemente der Psychophysik* had reached even its second edition. It is equally hard to see how one can write upon philosophy—upon monism and fundamental principles—and depend upon W. K. Clifford and Herbert Spencer as the chief authorities, never mentioning Kant, Fichte, Schelling, Hegel, Lotze, Wundt, or Avenarius.

MINOR STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF CORNELL UNIVERSITY.

COMMUNICATED BY E. B. TITCHENER.

XVIII. FLUCTUATION OF THE ATTENTION TO MUSICAL TONES.

By H. O. COOK, B. S.

In the *Anzeiger der Akademie der Wissenschaften in Krakau*, November, 1898, appeared an abstract of a paper by Dr. W. Heinrich, entitled *Zur Erklärung der Intensitätsschwankungen eben merklicher optischer und akustischer Eindrücke*. In the course of this abstract, Dr. Heinrich mentions, as a "ganz unerwartetes Resultat" of his experimental investigation, that minimal tones do not fluctuate ("dass bei Tönen keine Intensitätsschwankungen zu beobachten waren:" p. 374). Trial was made of the high tones of a Galton whistle, and of tones from the middle and lower regions of the scale given by organ-pipes and wide glass tubes. Dr. Heinrich himself was the sole observer (p. 373).

It is with this "wholly unexpected result," and not with any other of Dr. Heinrich's facts or hypotheses, that we are concerned in the present Study. The result seemed to need confirmation, for two reasons. In the first place, experiments upon the fluctuation of attention are regularly carried out in the drill-course in laboratory psychology (junior year) at Cornell University. The instrument employed during the past three years has been, not the watch, but Politzer's acoumeter (as supplied by Meyrowitz). The acoumeter gives a 'ting' or chirping tone which is said to be that of the c^2; we have not verified the pitch of our instrument.[1] At any rate, it gives a tone; and this tone has never refused to fluctuate. Secondly, Eckener had used as stimuli, in work upon the fluctuations of attention, (1) the fall of a fine stream of sand upon a vibrating steel tongue, which (as he says expressly) "einen hellen, singenden Ton erzeugte," and (2) the buzz of the Wagner ham-

[1] See the description in A. Politzer, *Lehrbuch der Ohrenheilkunde*, 3d ed., 1893, p. 108. S. Rowe, in *The Physical Nature of the Child*, 1899, p. 27, speaks of the acoumeter as giving a "tap on wood." We are not familiar with this form of the apparatus.

mer of an induction-coil, which must also have had a distinctly tonal character. Fluctuation occurred with both stimuli.[1]

In view of this discrepancy it seemed worth while to make a fairly extended series of experiments upon the question.

(1) *Sample of Results Obtained with the Politzer Acoumeter.*— We may preface the account of these new experiments by citing the results of two series taken with the acoumeter. The instrument is kept tinging at as constant a rate as possible (about 4 tones to the 1 sec.); the observer indicates disappearance and reappearance of the sound by finger movements; a third person, seated with a stop-watch (fifths of seconds) before him, well beyond the range of the observer's hearing, takes the time record.

TABLE I.

Stimulus: acoumeter. Duration of expt.: approx. 1 min. Interval between expts.: 2 min.

OBSERVER.	NO. OF FLUCTUATIONS.	AV. TIME HEARD (SECS).	M. V.	AV. TIME LAPSED (SECS).	M. V.
C. A. P.	50	9.8	4.2	4.8	1.8
J. H. W.	25	11.2	4.5	4.4	.7

The observers of this Table had both had more than the usual amount of practice in drill-work. The times are, of course, worthless, as absolute values; the point of the experiment lay elsewhere. But they were obtained under good acoustic conditions, and with all the carefulness that the rough method allowed.

A control series, taken with the two observers simultaneously, gave, as it happened, no single case of coincidence of finger-signals. The cause of the fluctuation could not reside, therefore, in objective changes in the intensity of the stimulus.

(2) *Experiments with Tuning-fork Tone.* An electro-magnetic fork of 1024 v. s. (Koenig) was connected through a suitable resistance to a storage battery. The current was set, roughly, at the strength required just to keep the fork in constant vibration. The fork and its resonator were covered by a large wooden box, and this again muffled in several thicknesses of cloth. The observer was placed in a corridor of the laboratory in a straight line with the sounding fork, and at a distance of 20 to 40 m., as circumstances demanded. Behind the fork, in a different room, a Ludwig kymograph was set up. A Jacquet chronometer wrote fifths of seconds on the drum, and an ordinary electro-magnetic time-marker, connected to a noiseless key under the observer's hand, recorded the fluctuations of attention. The noise of the clockwork was wholly

[1] *Untersuchungen über die Schwankungen der Auffassung minimaler Reize.* In Wundt's *Philosophische Studien*, VIII, pp. 358, 359.

inaudible to the observer. The muffled fork gave out a thin constant tone.

The position of the limen was first determined. Then the experimenter started fork, drum and chronometer, and signalled by a bell-stroke to the observer that an experiment had begun. The observer gave a short signal when he first heard the tone; then left the key-circuit open as long as he continued to hear it; closed the key when it disappeared; held the circuit closed until reappearance; and so on. A complete experiment lasted from 1.5-2 min.; but noises, inside or outside the building, frequently curtailed the periods. All work was done late at night or very early in the morning. No experimental series was carried to the fatigue-point.

A pause of 2-3 min. was allowed between experiment and experiment. During this interval the observer prepared his introspective record. All fluctuation-times were thrown out in which the moment of change coincided with an objective (sound in building, etc.) or subjective disturbance (coughing, need of changing position in chair, etc.). A few very short times were marked 'uncertain' by the observer: these were also discarded. Eckener's distinction of 'objective' and 'subjective' fluctuations came out clearly;[1] the objective were comparatively few in number, and all under 3 sec. duration. They were discarded for introspective reasons similar to those given by Eckener's observers. No time whatever was thrown out by the experimenter; the observer was sole judge. It fortunately never happened that there was any discrepancy between a drum-record and the introspective reconstruction of the experiment by the observer. Had there been, it was our intention to discard the whole experiment. Introspection was the one criterion of correctness.

The observers were Dr. J. O. Quantz (Q), and Messrs. W. C. Bagley (B), C. A. Perry (P), and J. H. Wilson (W). All fully understood the problem in hand, and were cognizant of psychological methods. The listening ear was turned directly towards the source of sound. B, Q and W closed the other ear with cotton-wool; P found this irritating, and therefore left the second ear open. The Table on the following page gives a summary of results.

Two control-series were made with two observers simultaneously, the fluctuation-curves being recorded by time-markers accurately adjusted to write together. Five experiments were taken with P and W: P gave 41, W 26 (subjective and objective) fluctuations. Four were taken with B and W: B gave 29, and W 33 fluctuations. The kymograph tracings

[1] *Op. cit.*, pp. 361 f.

TABLE II.

Stimulus: fork. Duration of expt.: 1.5-2 min. Total number of fluctuations for each observer: 100. Interval between expts.: 2-3 min.

OBS.	DIST. FROM FORK IN M.	AV. TIME HEARD (SECS).	M. V.	AV. TIME LAPSED (SECS).	M. V.
B	20-31	8.61	3.3	5.26	1.5
P	29-37	8.49	2.6	4.95	1.1
Q	31-37	9.10	2.9	5.51	1.4
W	23-38	7.87	2.4	5.41	1.5

show conclusively the general disparity of the two sets of fluctuations in each case. Coincidences are very occasional; and, even when they occur, are not always coincidences of subjective fluctuation. Hence there is no reason to doubt the conviction of observers and experimenter, that the fork did not vary in objective intensity during an experimental sitting.

(3) *Experiments with Tone of Blown Bottle.* Although the fact that tones fluctuate seemed to be fairly well proved by the foregoing experiments, we thought it well to test the matter further with other sources of sound. We began with one of the bottles of the Stern apparatus for continuous tone-change. The bottle gave, approximately, the c^1 of 256 vibrations. It was sounded steadily by a stream of air from the compressed-air tank belonging to the apparatus. It was covered by a wooden box, large enough not to interfere with the sounding of the tone; the box was muffled in cloth, as before.

We need cite only a single series: duration of expt. 1 min.

OBS.	NO. OF EXPTS.	AV. TIME HEARD.	M. V.	AV. TIME LAPSED.	M. V.
P	20	9.0″	2.4″	5.4″	1.9″

Similar results were obtained from P in other series, and also from a number of series with the observer W. A series of 10 expts. taken with P and W simultaneously showed the usual disparity, guaranteeing the objective steadiness of the bottle-tone.

We next made a few trials with the Galton whistle,—another of Dr. Heinrich's tone-sources. But, although we had about 45 m. of corridor at our disposal, we found it impossible, by any amount of muffling and door-closing, to get a satisfactory limen.[1] There were a few indications of fluctuation; but we can say nothing definite upon the matter. The squeaking chirp of the whistle is, however, so like the chirp of the acoumeter that there can be little doubt that the fluctuation would occur under the right acoustic conditions.

[1] These experiments were made so near the end of the academic year that we had no time to have a special 'soundless box' constructed, to take the instrument; we were forced to be content with the means of screening and muffling available at the moment. Next year we hope to be able to settle the issue finally, as regards the Galton whistle.

The question now arises: If tones fluctuate, as we have found them to do, how is it that so careful and practised an observer as Dr. Heinrich has been led to make a contrary statement? It is difficult to offer any suggestion. It is possible—despite the statement that the tone "auf der äussersten Grenze der Hörbarkeit" was "immer continuierlich und constant"—that Dr. Heinrich did not secure really liminal tone-intensities. It must be remembered that he was his own sole observer, so that an intercomparison of liminal distances was impossible. We found it an exceedingly nice matter, and one that called for a considerable degree of practice on the part of the observer, to determine the place of just-audible tone intensity. Our final method was to let the observer move to and fro until he thought he had found the limen; then to have him listen attentively for some 20 or 30 seconds; and then, if the tone was continuously audible (as generally happened), to push him out, little by little, until the real intensity-limen was obtained. Tones have a surprising carrying-power; and they are so sharply differentiated from the background of faint noise, against which they stand out, that the attention fastens to them easily and persistently.

There are, of course, other and considerable difficulties in the work. But Dr. Heinrich is probably as well aware of them as we are. He says explicitly: "Die Schwierigkeiten in der Beobachtung der Intensitätsschwankungen sind so erheblich, dass man immer längerer Uebung bedarf, um sie genauer verfolgen zu können" (p. 373). We need not enumerate these difficulties: we found nothing in any of them, whether technical or introspective, that could account for the divergence of results as plausibly as the suggestion thrown out above. We hope that Dr. Heinrich may be incited by our results to repeat his experiments upon a number of observers.

Summary.

We have found, in opposition to the statement made by Dr. Heinrich, that tones of liminal intensity, attentively followed by practised observers, evince the fluctuations ordinarily described as 'fluctuations of attention.' This rule holds of discrete (Politzer's acoumeter) and of continuous tones (tuning-fork, blown bottle). We were unable, under our laboratory conditions, to obtain a tone of the required minimal intensity from the Galton whistle.

PSYCHOLOGICAL LITERATURE.

Friedrich Nietzsche, Aphorismes et fragments choisis. Par H. LICHTENBERGER. Paris, F. Alcan, 1899. pp. xxxii, 181.

The author has put together in this little book some of the most striking parts of Nietzsche's work, under the following translated titles: *La naissance de la tragedie; Considerations inactuelles, choses humaines par trop humaines; Aurore; La gaie science; Ainsi parla Zarathustra; Par-delà le bien et le mal; La généalogie de la morale; Le cas Wagner; Le crépuscule des idoles; L'Antichrétien; Ecce Homo; Nietzsche contra Wagner;* and *Poésies;* not so much, he says, with a view of giving the reader an insight into Nietzsche's philosophy, as of presenting the philosopher "as a man, as a personality, as a poet." He would have his author appreciated for his moral nobility, and for his style as a writer, even if condemned as an illogical thinker.

A short sketch of Nietzsche's life is given, and the attempt made to show its harmony and, at bottom, its health physically and mentally up to the very moment of the great catastrophe which left him hopelessly insane. Complex as Nietzsche's mind seemed to be when analyzed, it nevertheless formed a unity. There was no internal struggle, no "anarchy of instincts," a sure sign of degeneracy. His views change radically, to be sure, in the course of his life. He loses his early Christian faith, and later his allegiance to the philosophy of Wagner and Schopenhauer; but the whole is an evolutionary, rather than a revolutionary process.

The development of Nietzsche's philosophy is also briefly reviewed. A positive and a negative tendency manifest themselves all through his life. Sometimes the one and sometimes the other has the ascendency. The positive element is one of enthusiasm, causing him to love, admire, reverence. The negative element, even more powerful, is critical, the result of the sincerity of his nature.

He passes from his crusade against scientific optimism, where he calls to aid Schopenhauer and Wagner, to a direct denial of his former position. M. Lichtenberger thinks it is a significant fact that this takes place at the time when he is physically struggling against disease, and attributes the outcome largely to the fact that the philosopher is essentially a sound man.

All the principal facts of Nietzsche's thinking are similarly dealt with, and are made fairly clear.

At the beginning of each 'fragment' is a short résumé of the whole article, and a statement of the special conditions under which it was written.

The book is appetizing. No one can read it and be content. A more simple and direct way to create an interest in Nietzsche and his works can hardly be conceived.

The Physical Nature of the Child, and How to Study it. By STUART H. ROWE, Ph D. New York, The Macmillan Co., 1899. pp. xiv, 207.

The great practical good that has come from the study of children is, after all, the creation of a certain attitude toward them. This attitude is well brought out in Dr. Rowe's *The Physical Nature of the*

Child, and How to Study it. Such a book could not have been written ten years ago; there was no material of which to make it. And even if written, it would not have been read; there was no interest in the subject.

This book *will* be read; yet one who has kept in touch even superficially with what is being discussed in the current educational magazine, especially in the *Pedagogical Seminary*, gets from it not a single new idea.

This does not mean that the book is not full of thought, and of good thought. It is a volume that ought to be in every Normal School library, and might profitably be read by the great majority of the teachers of the country. Less technical than its title seems to indicate, it deals with the general conditions of a child's life both at home and at school, as well as with the care of sight, hearing, touch, etc.

The book is emphatically 'common sense.' The author shows an acquaintance with much literature on his subject, and uses his material for the benefit of the every-day teacher in the every-day school. Many of his "tests" for sense defects are, as he frankly acknowledges, crude. Much that he says is common-place; but for that very reason, sandwiched in with less apparent truths, is valuable and forcible. For instance, he calls attention to the spread of disease by means of the common-drinking cup and the common towel; facts that every teacher ought to know and frown upon, but which still exist in all their primitive nastiness. There is no attempt at scientific accuracy, but when science is thought to point the way she is followed. The chapter on *Growth and Adolescence* is, perhaps, the most valuable of the work.

The book is clearly written and is paragraphed in sub-heads in a way to catch the eye. At the end is a rather long bibliography, largely made up of American educational magazines, followed by a good index.

Die moderne physiologische Psychologie in Deutschland. Eine historisch-kritische Untersuchung, mit besonderer Berücksichtigung des Problems der Aufmerksamkeit. By W. HEINRICH. Zürich, E. Speidel, 1899. pp. vii, 249. Mk. 4.

The second edition of this brilliant but one-sided little book has been enlarged by a section dealing with Exner's *Entwurf*, a concluding chapter, and an appendix replying to criticisms by Külpe and Hillebrand; while the section on Wundt has been considerably modified. The revision shows all the dogmatism of the previous edition; there is the same arbitrariness in the selection and omission of books and authors, and the same incapacity to envisage a psychological system as a whole. But if the author is a gadfly, he is one that cannot be all too easily brushed aside. His objections and reproofs must be met, and met by hard thinking. For this reason the work is most welcome. It may, perhaps, be hoped that in yet another edition Dr. Heinrich will extend the range of his vision and consider French and American theories of attention.

Untersuchungen ueber das Gedächtniss für räumliche Distanzen des Gesichtssinnes. ZWETAN RADOSLAWOW-HADJI-DENKOW. *Philos. Studien* XV, 3. pp. 318-452.

This article is based on experiments carried on in the Leipzig Laboratory in 1896-7. It attempts to answer two questions, viz.: (1) What is the exact influence of time on visual memory for distances? and (2) what effect upon the memory proceeds from the character of the filling introduced into the interval of retention?

(1) After citing the work of E. H. Weber, W. Lewy and J. Cĕlikov on visual memory the author sets forth the relation which obtains

between the quantitative accuracy of memory (Gedächtnissschärfe) and the length of the memory interval. He used as stimulus a lateral distance (usually ca. 30 mm.) limited by two black dots, one of which was attached to a framed pane of glass, and the other to a white card immediately behind the glass, and adjustable laterally by means of a micrometer screw. The method of minimal changes (without knowledge of direction) was used throughout (except one series by R. & W. cases). Values for both the upper and lower limina were obtained with 13 intervals (1″ to 60″). It was found that "within certain limits the accuracy of memory [indicated by the magnitude of the limina] is approximately proportional to the logarithm of the time:" this for normals of 30 mm. and 40 mm. Small irregularities on the logarithmic curves are referred to accidental coincidences of the stimulation time with various phases of the attention wave. Large irregularities—lowering of the limen—(similar to H. K. Wolfe's: cf. *Ueber das Gedächtniss*) give expression, in the author's opinion, to a peculiarity (bestimmte Eigenschaft) of the memorial function: they indicate an intermittent strengthening of the memorial image (446). The most apparent lowering of the difference limen occurs after 30″. (2) In previous experiments the direction of the attention was not controlled during the retention interval, though the eyes were closed and the observers declared that the image of the normal stimulus was seldom present: to estimate accurately the effect of the conscious filling of the interval, various forms of stimulation—metronome and bell strokes, grays, colors and reading (Zwischeneindrücke)—were introduced when the normal was removed. It was found that, under these conditions, the memory, instead of falling off, improved—$\triangle$r for the various intervals decreased.[1] This "unexpected" result the author explains as follows. Just as a perception is dimmed by a stimulus acting continuously for a long time, memory suffers if a single idea is steadily held in the attention. But if the attention is held away (by Zwischeneindrücke, *e. g.*) from the memorial contents, the latter remains clear and fresh. The withdrawal of the attention, he conjectures, means that the psychophysical energy is left undisturbed in the memory center (369), and hence that the memory, as a cerebral disposition is kept intact. A constant reproduction, on the other hand, exhausts the psychophysical energy, and memory is weakened. Three objections may be offered to this rather tenuous explanation. (1) The obscurity noted in perception is very likely to be due to peripheral processes which are not in evidence in the case of memory. (2) According to the introspection of the subjects, as indicated above, the idea of the normal "never or only rarely, and then very indistinctly" (449) appeared in consciousness during the interval. Indeed, the author asserts that the two incentives to reproduction are (*a*) the comparison-stimulus and (*b*) eye-movements accompanying its appearance (450). (3) It is extremely doubtful whether the Zwischeneindrücke—sounds, colors, etc.—furnished an adequate distraction: even addition has been found to produce only a partial and intermittent abstraction.[2] Probably these heterogeneous sensations (unless some unrecorded precaution was taken) really acted as a spur and kept the mind alert.

The fact that a j. n. d. becomes subliminal on the increase of the

[1] N. Vaschide has remarked that distraction favors memory for lines. *Dritter Intern. Cong. für Psych.*, p. 455.

[2] Cf. A. J. Hamlin who remarks that an intermittent distraction is no distraction, for it is the degree and not the duration of the attention that affects the judgment in S. D.: in fact, "the so-called distraction . . . . by adding definiteness and interest to the task heightens the degree of attention." *Attention and Distraction*, pp. 5 ff.

retention interval (as the logarithmic curve shows) leads R-H-D to a distinction between *ideal* and *absolute* memories. In the former, a j. n.d. would remain liminal through any interval of time; in the latter, supraliminal differences beyond a certain magnitude are retained through an indefinite lapse of time. The author argues, from the memory curve, that an ideal memory is an impossibility, and also that all memory limina (*i. e.*, difference limina at the various intervals) lie below absolute memory, *i. e.*, between ideal and absolute memory, but approach the latter as the time interval increases. The contraction of an ideal memory was guarded against in the experiments by a daily shifting of the normal stimulus; but since it was found that the constant use of a single normal throughout a working period did not tend to develop it, the author concludes that the precaution was useless. This is significant, since it seems natural that the direct effect of practice (as *e. g.*, the repetition of an N in the method of average error) should be the formation of a stereotyped memory that would carry a liminal difference through an extended lapse of time;[1] that is, tend to produce an ideal memory. In fact, one of R-H-D's subjects shows plainly such a tendency. Tyszko (408) takes first a series beginning at the 60″ interval and running down to 1″. The liminal values (average of o.L. and u.L.) are for 60″—1.235 mm.; for 1″—.46 mm., while a second series taken in the opposite direction gives the values: for 1″—.45 mm.—; for 60″—.675 mm.

The limit of absolute memory (Grenzunterschied) was found by getting the limina at a constant short interval through which the subject observed a lateral distance (Zwischendistanz) = or ≷ the normal. As this distance approached the normal it disturbed the limen by (1) obliteration of the memory image of the normal, and (2) by confusion with this image. As it receded from the normal (becoming greater or less) its disturbing influence on the latter ceased at a certain point, which represents for the author the lower limit of absolute memory; *i. e.*, the smallest difference which persists indefinitely (presupposing a constant degree of practice). It is clear that this method will be valid only where no qualitative change of the memorial residue is brought about through time; moreover, it does not seem to follow that the confusion due to an interpolated stimulus, lasting for 10″ or 20″, would be equivalent in its effect upon the limen to an ordinary interval of indefinite length. The coincidences given in the text are too rough (if we accept the logarithmic form of the memory curve) to be convincing.

Finally, the author notes that two objectively equal stimuli, when given successively, tend to elicit the judgment "greater." He decides that this overestimation of the second stimulus is due to a peripheral factor and not to a change in the memory image, as has often been held in similar cases.[2] The peripheral influence — variable muscular strains —is shown very ingeniously to be an indubitable cause in the overestimation. It does not, however, explain an almost constant disparity in the magnitudes of the upper and lower limina: the lower is in almost every case smaller. For this there is found no satisfactory explanation (353). The reasons brought against the lack of fidelity of the image are too involved to be discussed here. They seem to the writer to be insufficient. Our own reason would be that no memory image has been shown to exist in the experiments in question. The author states that often a feeling seems to be the only warrant for the assurance experienced with a judgment of likeness or difference. May

[1] Cf. pp. 35-6 *supra*.
[2] Note p. 36, *supra*.

it not be that this feeling replaces the explicit comparison between the perception and the image and itself validates the judgment?

I. M. BENTLEY.

A Primer of Psychology. By EDWARD BRADFORD TITCHENER. The Macmillan Co., New York, 1899, pp. xvi, 316.

The first edition of this admirable introduction to Psychology has already been noticed in the JOURNAL (vol. X, p. 150). The new edition has been thoroughly revised, several sections having been rewritten in whole, or in part, and an appendix has been added giving a résumé of Flechsig's scheme of cortical centres. The scope and general treatment of course remains unchanged.

NOTES AND NEWS.

THE PARIS CONGRESS.

The programme of the fourth International Congress of Psychology to be held in Paris August 20-25, 1900, is to hand, and gives the following details of organization.

Intending members are requested to fill out a printed form (obtainable from the American members of the International Council: Professors Baldwin, Stanley Hall, James and Titchener), and to forward it with 20 fr. membership fee to the general secretary, M. le Dr. Pierre Janet, 21 rue Barbet-de-Jouy, Paris. The card of membership entitles its holder to all the publications of the Congress, and also gives right of entry to various laboratories, museums, hospitals, etc. Railroad reductions of 40 per cent. are expected during the exposition. Communications may be written in English, German, French or Italian; no communication must exceed 20 minutes in duration. Titles of communications are desired, at the latest, by Jan. 1, 1900. Sections and presidents are as follows:

I. *Psychologie dans ses rapports avec l'anatomie et la physiologie.* Dr. M. Duval.
II. *Psychologie introspective dans ses rapports avec la philosophie.* M. G. Séailles.
III. *Psychologie expérimentelle et psychophysique.* M. A. Binet.
IV. *Psychologie pathologique et psychiatrie.* Dr. Magnan.
V. *Psychologie de l'hypnotisme, de la suggestion et questions connexes.* Dr. Bernheim.
VI. *Psychologie sociale et criminelle.* M. Tarde.
VII. *Psychologie animale et comparée, anthropologie, ethnologie.* M. Y. Delage.

A local committee of reception, including thirty well-known names, has been formed: we regret to record the fact that Professor Balbiani has died since the list was prepared. The officers of the Congress are: President, Professor Th. Ribot; Vice-President, Professor Ch. Richet; General Secretary, Dr. Pierre Janet; and Treasurer, M. Felix Alcan.

Information concerning related Congresses may be obtained as follows: Philosophy, M. Xavier Léon, 39 rue des Mathurin; Social Sciences, M. Dick May, 22 rue Victor Massé; History of Religions, MM. J. Réville and L. Marillier, Sorbonne, Paris.

PSYCHOLOGICAL CARD CATALOGUE.

The following circular has been sent out by Prof. James H. Leuba, of Bryn Mawr College:

A card catalogue of articles on Psychology and Related Subjects contained in periodicals for the years 1860-1899.

To prevent the grievous waste of time suffered year after year by psychologists in looking up the literature of the particular subjects on which they may be engaged, and to bring to their knowledge the wealth of material consigned to, and in large part buried in, the numerous periodicals containing psychological material, the undersigned has prepared a card catalogue of the articles bearing upon psychology contained in the following periodicals, beginning with the year 1860, or with the first volume of the periodical, and including 1898, unless otherwise indicated in the list:

Philos. Studien; Zeitschrift f. Psy.; Arch. f. Syst. Philos.; Vierteljahrss. f. wissenschaftliche Philos.; Zeitschrift f. immanente Philos.; Zeitschrift f. Philos. and philos. Kritik.; Philos. Jahrbuch (Vol. 4-7); Zeitschrift f. Philos. and Pädagogik; Zeitschrift f. Hypnotismus; Psy. Arbeiten; Münsterberg's Beiträge; Mind; Proc. Soc. Psy. Research; Amer. Jr. Psy.; Psy. Review; Rev. philosophique; Année psychologique; Rev. de Metaphysique et de Morale, Rev. de l'Hypnotisme; Rev. neo-scholastique (Vol. 3-5); Studies of the Yale Psy. Laboratory; Intern. Jr. of Ethics; Monist; Science (from beginning); Nature (from beginning); Amer. Jr. of Science (from beginning); Pop. Sc. Mo. (from beginning); Proc. Roy. Soc. (from beginning); Philos. Mag. (from beginning); Phil. Tran. (from beginning); New World; Brain; Jr. of Mental Science (1863-1898); Amer. Jr. of Insanity; Allg. Zeitschrift f. Psychiatrie; Bull. de la Soc. d'Anthrop. de Paris (Vol. 1-6, 1st Ser., and Vol. 1-9, 3rd Ser.); L'Anthropologiste; Rev. mens. de l'Ecole de l'Anthrop.; Arch. de l'Anthrop. criminelle; Amer. Anthrop.; Jr. of Amer. Folk-Lore.

It is hoped that the catalogue will be made practically complete at some future time by the addition of the contents of a number of other periodicals.

The catalogue numbers about 10,000 cards. We have frequently gathered on one card references to several articles on one subject by different, or by the same author, so that the number of articles indexed surpasses considerably the number of cards.

Our endeavor has been to keep the catalogue free from matter extraneous to its purpose and, at the same time, to include in it everything having a clear bearing upon psychology taken in a wide sense. For this reason a majority of the papers which would come more directly under the heads metaphysics, ethics, and logic, have found place in it.

We have excluded the reviews of books, with a few exceptions; the papers on the history of philosophy; the reports of institutions, congresses, etc., except when of particular value; and the discussions of consequence to the author's only.

The classification is by subjects arranged in alphabetical order. The general heads are divided into as many subdivisions as seems useful. To facilitate the use of the catalogue a large number of cards have been classified under several heads by means of cross reference cards. Special care has been taken in this matter so that the answers of the catalogue to the person consulting it may be prompt and to the point.

The card system makes it possible to keep the catalogue up to date, year by year, without more trouble than the cutting and pasting, on cards of the proper size, of the titles indexed in the excellent bibliography issued yearly by the *Psychological Review*. (Published since

1894.) The cards used are supplied by the Library Bureau, which has branches in the larger cities of Europe as well as in this country; thus uniformity of size and of material can easily be maintained.

We are now endeavoring with the collaboration of several psychologists to add short annotations to the cards, though the difficulty and the magnitude of the task may compel us to give it up, in part at least.

The cost of the catalogue described in the circular, if printed, would be beyond what most colleges and universities could afford to pay, but, if a sufficient number of subscribers were found, mimeographed copies in the clear hand known as "Library Hand" could be furnished at the price of from $40 to $50, according to the number of subscribers.

You are respectfully requested to let the undersigned know, at your earliest convenience, whether you desire a duplicate at that price. Copies ordered subsequently and having to be executed singly would, of course, cost a great deal more.

JAMES H. LEUBA, Ph. D.,
Bryn Mawr College,
Bryn Mawr, Pa.

BOOKS.

Professor James' *The Will to Believe* is in course of translation into German, and Professor Baldwin's *Story of the Mind* into French and Italian.

The first volume of Professor Titchener's *First Experiments in Psychology* is announced for January. It will contain about 50 qualitative experiments, worked through in minute detail, with references to literature and apparatus, additional exercises, directions for recording, etc., etc. The instruments required for the course will be furnished by the Chicago Laboratory Supply Co.

PERSONAL.

We regret to record the deaths, on July 31, of Dr. D. G. Brinton, Professor of American Archæology and Linguistics in the University of Pennsylvania, and, on June 14, of Professor N. Grote, of the Moscow University, the distinguished editor of *Voprosy philosophii i psychologii*, and President of the Psychological Society of Moscow; as well as that of M. Balbiani, Professor of Comparative Embryology in the Collège de France, mentioned in a previous Note.

Professor Max von Frey has been called from Zurich to fill the chair of physiology vacant at Würzburg by the resignation of Professor A. Fick. With von Frey, Külpe, Marbe and Schenck, Würzburg should become a psychophysical centre of first-rate importance.

Professor J. M. Baldwin has been given a half year's leave of absence from Princeton University, to see the Dictionary of Philosophy and Psychology through the press in England. His courses at Princeton will be in the hands of Professor H. C. Warren.

During Professor Armstrong's absence from Wesleyan University the department of philosophy and psychology will be in charge of Associate Professor R. Dodge.

Dr. A. Kirschmann has been appointed Professor of Philosophy and Director of the Psychological Laboratory in the University of Toronto.

BOOKS RECEIVED.

CARPENTER, GEORGE H. Insects: Their structure and life. A primer of entomology. J. M. Dent & Co., London, 1899. pp. 404.

HALDANE, E. S. James Frederick Ferrier. (Famous Scots Series.) Imported by Charles Scribner's Sons, N. Y., pp. 158. Price, 75 cents.

HEINRICH, W. Die moderne Physiologische Psychologie in Deutschland. Eine historisch-kritische Untersuchung mit besonderer Berücksichtigung des Problems der Aufmerksamkeit. E. Speidel, Zürich, 1899. pp. 249. Price, 4 marks.

HEINRICH, W. Zur Prinzipienfrage der Psychologie. E. Speidel, Zürich, 1899. pp. 74. Price, 2 marks.

LICHTENBERGER, HENRI. Friedrich Neitzsche, Aphorismes et fragments choisis. Félix Alcan, Paris, 1899. pp. 181. Price, Fcs. 2.50.

Morale Sociale. Leçons professées au collège libre des sciences sociales. Préface de Emile Boutroux. Félix Alcan, Paris, 1899. pp. 318. Price, Fcs. 6.

PATRICK, MARY MILLS. Sextus Empiricus and Greek scepticisms. George Bell & Sons, London, 1899. pp. 163. Price, 5 shillings.

SNIDER, DENTON J. The will and its world. Psychical and ethical. Sigma Publishing Co., St. Louis, Mo., 1899. pp. 575. (For sale by A. C. McClurg Co., Chicago, Ill.)

TIENES, GEORGE A. Nietzsche's Stellung zu den Grundfragen der Ethik genetisch dargestellt. Reprint from Berner Studien zur Philosophie und ihrer Geschichte. Band 17. C. Sturzenegger, Bern, 1899. 50 pages. Price, 1.75 marks.

MIND: NEW SERIES.

A Quarterly Review of Psychology and Philosophy.

Edited by G. F. STOUT,

With the co-operation of PROFESSOR H. SIDGWICK, DR. E. CAIRD and PROFESSOR J. WARD (England); PROFESSOR TITCHENER (U. S. A.)

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There also appears, under the head *Philosophical Periodicals*, a list of the titles and an indication of the contents of the articles in the leading philosophical journals, English and foreign, with a further notice of those which appear to be of special importance. *Notes* on recent researches and current news conclude each number.

All communications to the editor from Europe should be addressed to: G. F. STOUT, *The University, Oxford;* those from America to E. B. TITCHENER, *Cornell University, Ithaca, N. Y.*

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